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SPECIAL OPERATIONS FORCE SELECTION IN

CRISIS: A KERNEL DECISION SUPPORT SYSTEM

THESIS

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Captain, USA

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Approved for public release: distribution unlimited.

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SPECIAL OPERATIONS FORCES SELECTION IN CRISIS: A KERNEL DECISION SUPPORT SYSTEM

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Operations Research

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Captain, USA

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Preface

The purpose of this research was to investigate the development of a decision support system to support military mission planners in selecting the most capable and available special operations unit for use in a contingency operation. The adaptive design methodology was used to develop a kernel system to serve as a working testbed for the mission planners around which a fully operational planning aid could eventually be developed.

The system generated by this research was named PLANNER Ver. 0 and serves as a "first cut" attempt at designing decision aids for operational planners using off-the-shelf software and hardware products. While the system is not capable of fully supporting operational planners in its current form, it does provide a start point for the application of the adaptive design methodology to military decision aiding.

In attacking this somewhat "fuzzy" problem I had a great deal of help from others. I am deeply indebted to CPT Tom Hayden of USSOCOM for providing the impetus behind this thesis and the information to get started. LTC J. R. "Skip" Valusek served as my thesis advisor. He provided the carrot when necessary and applied the stick as required in order to keep me on track and in line. Without LTC Valusek's support this thesis might never have been completed. MAJ Dan Reyen, USA, served as my reader and my "green suit" sanity check during this research and for this I am indebted. I also

feel the need to thank the folks at the OJCS-J8 and the Combat Analysis Group at U.S. CENTCOM for their input and advice. I would also like to thank the members of AFIT class GST-88M for their good natured approach to the AFIT experience and their willingness to always lend a hand when needed. Finally, I would like to express my deepest thanks and admiration for my wife Susie whose tolerance, generosity, and strength have allowed her to endure the nomadic life of a Cavalry Trooper's wife and still come out smiling. Without her loving support and dedication I would be much less than I am today.

William J.A. (Joe) Miller

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Abstract

The purpose of this ~~research~~ was to investigate the development of a decision support system to support military mission planners in selecting the most capable and available special operations unit for use in a contingency operation. The adaptive design methodology was used to develop a kernel system to serve as a working testbed for the mission planners around which a fully operational planning aid could eventually be developed.

The system generated by this research was named PLANNER Ver. 0 and incorporates a spreadsheet, relational data base, and expert system to support the unit selection process. PLANNER calculates the distance and time to target for the units available to the mission planners and updates the data base with this information for each unit. PLANNER provides the mission planner with the opportunity to browse the data base or elicit help from the expert system, which uses a set of pre-determined selection rules, in order to select a unit for the mission. The ultimate goal of PLANNER is to help a mission planner do his job more efficiently, effectively, and consistently.

PLANNER serves as a 'first cut' attempt at designing decision aids for operational planners using off-the-shelf software and hardware products. While the system is not capable of fully supporting operational planners in its

current form it does provide a start point for the application of the adaptive design methodology to military decision aiding.

This research indicates the adaptive design methodology coupled with end-user-computing may hold great promise in the development of decision aids to support operational planners.

Copyright Acknowledgement

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Special Operations Forces Selection In Crisis: A Kernel Decision Support System

I. Introduction

Background

Special Operations Forces (SOF) in the United States are as old as the military establishment itself. Military policy makers have long recognized the need for specially trained troops to strike rapidly where the enemy least expects. History has seen SOF evolve from the rock hard, weathered volunteers of Roger's Rangers to the highly trained, technically adept professionals of today's SOF community. Today's SOF units are capable of conducting missions ranging from raids or attacks against strategic targets in a total war scenario to providing tactical support and training to a host nation in a low intensity conflict.

Historically, during periods of overt war, SOF units were deemed essential in order to successfully prosecute the conflict on all fronts. This is evidenced by the rapid build-up of units such as the Army Rangers and Marine Raiders during World War II to the explosive expansion of the Army Special Forces structure during the Viet Nam conflict. Yet, as soon as the conflict was terminated, SOF units experienced dramatic reductions in manpower and

priority in favor of more conventional forces [3:1]. This reduction in SOF was generally driven by two factors: the threat to national security as seen by top level policy makers within the government and the desire to reduce military expenditures as rapidly as possible during post conflict times. During the post World War II era military policy makers became concerned with what they perceived as the immediate threat to national security which was generally viewed as another total war. Hence, priority was given to maintaining a conventional force of appropriate size to deter the next war.

During the 1950's and 1960's conventional forces felt the same types of force reductions that SOF had known for years in favor of the strategic nuclear forces. Resources were poured into developing a formidable nuclear deterrent which could be dangled like the "Sword of Damacles" over any potential enemy. The policy known as "massive response" severely limited the United States' ability to deal with the range of crises that might present themselves and ushered in the age of Mutually Assured Destruction (MAD), whereby the United States and the U.S.S.R. accumulated massive nuclear inventories and based their entire national military policy on the use or threatened use of these stockpiles. The policy makers on both sides realized the flaws in this type of policy and began to reorient their foreign and military policy to provide more flexibility in responding to military confrontations. For the United States, this led to the

"doctrine of flexible response" where the national command authority could respond to a crisis with an appropriate level of force without having to immediately escalate to the use of nuclear weapons. This policy of "flexible response" began to drive a massive build in conventional forces which has lasted until the present.

The discussion above demonstrates how the perceived and real threats to national interests drive our national military strategy. Our leaders commit resources and establish priorities for organizations which they feel are most capable of protecting the United States interests based on the threats, perceived and real, to national security.

SOF are experiencing a renewed emphasis in the national strategy just as our conventional forces did in the 1960's. This renewal has occurred because SOF are perceived as being more capable of dealing with the threats which are most likely in today's world. To illustrate this we need only look at the spectrum of conflict model (Figure 1) which represents warfare on a continuum and relates types of conflict to the probability of occurrence and the risk to society.

While SOF units have been traditionally considered strategic assets, they are capable of being employed in strategic and tactical roles and can therefore be used in conflicts ranging from terrorism to total war.

The preceding discussion highlights two main reasons for the renewed emphasis on special operations forces in the

United States' force structure. First, the flexibility afforded policy makers by SOF allows the U.S. more leeway in the employment of military force to resolve a crisis situation.

```
<<---------------------------------------------------------------
  INCREASING <--------- PROBABILITY -----------------------------
<<---------------------------------------------------------------
:                                                               :
:  Terrorism  Unconventional   Conventional   Nuclear           :
:                Warfare          Warfare      Warfare          :
:                                                               :
:                                                               :
--------------------------------------------------------------->>
-------------------------- RISK ----------------> INCREASING
--------------------------------------------------------------->>
```

Spectrum of Conflict
Figure 1
(Adapted from SOTACA Analyst's Guide to Theory)

The presence of a vigorous, multi-role special operations capability gives the U.S. an alternative to the employment of large conventional forces or nuclear force posturing. As Haas has stated, the political fallout due to the employment of conventional forces may be so costly that the employment of SOF may be the only acceptable option open to the U.S. administration in a crisis situation [5:110]. Second, the pressure to decrease the cost of maintaining the U.S. force structure while meeting worldwide commitments has made SOF more attractive to force planners. While SOF units are generally more expensive to raise and maintain than conventional units, their ability to be employed in a

variety of scenarios and conflicts may well make them the most economical assets in the strategic arsenal. [3:111]

Given the emergence of SOF as a viable component of the force structure and the threats facing the United States today the following discussion points out the need to improve our crisis planning capability with regard to special operations forces.

Crisis Action Planning

Crisis action planning is executed in response to a specific crisis. A crisis is defined as:

> ... an incident or situation involving a threat to the United States, its territories, and possessions that rapidly develops and creates a condition of such diplomatic, economic, political, or military importance to the U.S. government that commitment of U.S. military forces and resources is contemplated to achieve U.S. national objectives [7:7-3].

Once a crisis has been declared, crisis action planning is conducted within the Crisis Action System (CAS). The CAS is a set of people and procedures connected to insure rapid flow of information between the concerned agencies and allow the rapid construction of a plan to resolve the crisis [7:7-1+]. This system is a direct response to the realization that the world situation changes in a rapid, unpredictable, and unstructured manner yet planners must have a means to assess and remedy the undesired situations in a timely manner.

In the past three decades crises seem to be the rule rather than the exception. The Cuban Missile Crisis of 1962, the seizure of the S.S. Mayaguez in 1975, the seizure of the U.S. embassy in Tehran in 1979, the intervention in Grenada in 1983, and the attack on the U.S.S. Stark in the summer of 1987 are only a few examples of crisis situations where the use of military force was contemplated or initiated. During the same period the U.S. was not called upon to execute any of its major war plans. The evidence is clear on one point, the majority of situations where the use of U.S. military force has been contemplated or applied in recent times have been considered crisis situations.

Given the current world climate it appears there is no reason the state of the world will become any more predictable in the future. Consequently, probability of the U.S. becoming involved in crisis situations is not likely to abate. On the contrary, crisis situations are likely to increase given the emergence of third world countries as truly independent nations and the extension of Soviet "good will" in order to bring these emerging nations into the fold.

USSOCOM

In 1987 the United States Special Operations Command (USSOCOM) was activated as a Unified Command and charged with establishing a coherent joint special operations

training, planning, and resourcing capability. USSOCOM has the following major missions:

1. Provide combat ready special operations forces (SOF) for rapid reinforcement of other unified commands.

2. Plan and conduct selected special operations, if so directed by the President or Secretary of Defense. (Note: USSOCOM will not deploy as a Joint Special Operations Task Force (JSOTF) headquarters. Rather, a service component or special operations component of a Unified Command would assume the duties of forward headquarters.)

3. Develop joint doctrine, tactics, techniques, and procedures for Special Operations.

4. Conduct specialized courses of instruction for all SOF.

5. Conduct training of all assigned forces and insure interoperability for any level of conflict.

6. Monitor the procedures of SOF assigned to other Unified Commands.

7. Monitor the promotions, assignments, retention, training, and professional development of all SOF personnel.

8. Develop and acquire unique special operations materiel, supplies, and services.

9. Consolidate and submit program and budget proposals for major force program category 11 [6].

USSOCOM's role is that of a force trainer and force provider. It falls within USSOCOM's purview to establish

the doctrine and methodologies for the employment of SOF by the warfighting CINCs. USSOCOM will act as an arbiter to ensure all SOF doctrines developed by its service components are compatible and support the concept of joint interoperability. USSOCOM's mission charter and the current predisposition toward crises in the world make it clear that it is a necessity for USSOCOM to establish a coherent methodology for the employment of SOF in crisis situations. This methodology should allow the unified commands or JSOTF to select and plan for the use of the most capable SOF unit for the mission.

Within the mission statement of USSOCOM is the problem of selecting the most capable or best SOF unit for use in a contingency, which is not a simple problem. There are several factors which must be considered when selecting a unit. They include but are not limited to: unit capabilities; unit availability; and unit supportability.

Unit Capabilities. Currently, there are several types of SOF units available to planners for use in crisis situations. Each service has its own set of special operations units and each of these units has its own unique set of operational capabilities. However, many of these units also have overlapping capabilities. For example SCUBA qualified Army Special Forces detachments and Navy SEAL teams are both capable of ingress from the sea. By the same token, some units have "one of a kind" capabilities such as the Air Force Combat Talon units. A critical component of

the SOF selection process is to determine which units are capable of accomplishing the mission.

Unit Availability. Each SOF unit has its own training requirements and schedules. While one unit is deployed on a training exercise or operational mission, others might be at their home bases or enroute to or from a mission. The questions the planner must answer are: Is the unit available for the mission? If so, can the unit be inserted into the target area within an acceptable amount of time?

Unit Supportability. Every unit has a unique set of support requirements. Planners must be able to rapidly assess the supportability of SOF units in terms of strategic lift requirements, communications requirements, pre-mission training, special equipment requirements, medical requirements, and other key areas not mentioned here. Simply put, the planners must know if they can get the force to the target with the equipment and support it needs to accomplish the mission within an acceptable time limit.

Planners must accomplish three tasks when selecting the best SOF force for use in a contingency operation.

1. Planners must clearly understand the unique capabilities of the units available to them in order to select the most capable SOF unit for the mission. This must be accomplished in the absence of all parochial interests.

2. Planners must determine which of the "most capable" units is reasonably available for the mission. The planners must ask: where are these units and can they be inserted

into the target area within the time constraints imposed on the plan by the tasking command?

3. Finally, planners must determine if they can provide the capable/available units with the support necessary within the the mission's time constraints.

These questions must be answered quickly and completely to ensure the selection of the proper unit(s) for the mission and the most judicious use of the United States limited SOF assets.

Research Problem

USSOCOM is tasked with developing the doctrine for the employment of SOF during times of conflict. The current world situation is such that crises are the norm for the application of military force. Given the limited SOF capability the United States possesses, it may be useful to investigate the use of computer aids for the selection of SOF units in crisis situations.

Research Objectives

The objectives of this thesis are:

1. To initiate a decision aid to assist planners in selecting the most capable SOF unit(s) for use in a crisis situation;

2. To investigate adaptive design as a process to build and maintain the force selection decision aid;

3. To investigate the use of commercial off-the-shelf software and hardware to design and build the decision aid.

Chapter II discusses three topics: 1) Past solution efforts for the force selection in crisis planning problems; 2) Decision support systems; and 3) The adaptive design process.

II. METHODOLOGY

Introduction

This chapter discusses past research and solution attempts for the selection of SOF units during crisis situations and the problems encountered. Chapter II then discusses the concept of decision support systems and their application to the problem. Finally, Chapter II examines the adaptive design methodology for decision support systems and its application to the SOF selection problem.

Past Research and Solution Attempts

To the best of the author's knowledge there has been no research into the problem of how to select the best SOF unit for use in a contingency mission. However, research has been initiated, under the auspices of the Modern Aids to Planning Program (MAPP), to support the force planning process in general.

MAPP was initiated in 1982 by GEN John Vessey, then Chairman of the Joint Chiefs of Staff. The purpose of this program is to provide the warfighting CINCs with "...'modern' capabilities to improve their ability to analyze and develop war plans" [9:2]. The first results of this initiative to reach the operational commands were the Joint Theater Level Simulation System (JTLS) and the State Of The Art Contingency Analysis system (SOTACA).

JTLS is intended to provide a method for the CINCs to analyze their large scale, deliberate war plans. JTLS is a hex-based attrition model with the primary measures of effectiveness being force attrition and logistic consumption [13]. It is a very detailed combat simulation which allows the CINC's staff to war game courses of action in order to provide insight into the possible outcomes of each course of action were it selected for use. It indirectly allows planners to select the best unit for a mission by comparing the results of simulations using different types of units during separate runs of the same scenario. It is a huge model requiring as much as six months to prepare the necessary files for a single run and several weeks to properly run and analyze the outcomes. Its focus is primarily on conventional forces and their application at the theater level. Its size, speed, and focus on conventional forces make it inappropriate for use in contingency operations where SOF units are involved.

As its name states, SOTACA focuses on the analysis of contingency operations at the theater level. It is intended to give the CINCs a way of quickly analyzing the various courses of action available to them in a crisis situation. SOTACA is a network based attrition model with the primary measures of effectiveness being force attrition and force movement. SOTACA allows the planner to assess the relative effectiveness of units based on their "performance" in the scenario modeled [10]. As with JTLS, SOTACA is primarily

concerned with the assessment of conventional forces although efforts are under way to apply SOTACA to Special Operations Forces.

Both JTLS and SOTACA focus on the assessment of units in a combat scenario relative to a specific opposing force. JTLS and SOTACA are primarily concerned with the units' capabilities to perform the assigned mission, not why those units were chosen to perform the mission. They simply provide the results of a combat simulation for analysis by the planners. Neither of the systems is concerned with assessing the units' inherent combat capabilities before the simulation nor are they concerned with how the units were selected for use in the course of action being modeled.

The Joint Operational Planning and Execution System (JOPES) increment 1 is a system intended to aid high level staffs and agencies in the joint planning arena. The characteristics of JOPES are:

> JOPES is being developed as a unified planning and execution system which will capture and integrate current planning capabilities, particularly those found in JOPS and JDS. Building on this foundation, JOPES will add new capabilities addressing deployment, employment, sustainment, and mobilization. JOPES will prescribe one set of planning procedures to be applicable in both deliberate and crisis situations. It will employ modern WIS ADP support which will materially enhance the accessibility and quality of information available and will support decision makers through the use of analytical tools and simulation [8:21].

Upon its completion, JOPES will be a huge and extremely complex system of communications and ADP equipment designed to enhance the entire war planning process. JOPES will

eventually have the ability to assist decision makers in the assessment of unit capabilities through data base browsing and simulation. However, it will not specifically address the how and why units are selected for specific missions [8].

To the best of the author's knowledge, the ability to help planners select forces based on their capabilities, readiness, and training has yet to be incorporated into these or any other operational planning aid.

Decision Support Systems

The concept of Decision Support Systems (DSS) is relatively new and somewhat controversial in the world of management information systems. Consequently there is no universally accepted definition of what a DSS is. In general, DSS are seen as tools designed to aid a decision maker in solving problems which are not well structured (semistructured or unstructured) and non-routine or repetitive. Semistructured and unstructured tasks are ones where the decision maker's knowledge about the problem, environment, resources, and the value of alternative courses of action is uncertain. Alavi and Napier define DSS as "...computer based systems designed to enhance the effectiveness of decision makers in performing semistructured tasks" [1:21]. Valusek defines a DSS as "...a system, manual or automated, that supports the cognitive processes of judgment and choice." [13] In what

is considered a seminal work on DSS design to date, Sprague and Carlson chose not to define a DSS but instead define the characteristics a DSS should possess. These characteristics are:

1. They tend to be aimed at less well structured, underspecified problems that upper level managers typically face.
2. They attempt to combine the use of models or analytic techniques with traditional data access and functions.
3. They specifically focus on features that make them easy to use by noncomputer people in an interactive mode.
4. They emphasize flexibility and adaptability to accommodate changes in the environment and decision-making approach of the user [2:6].

A DSS can be considered a "tool bag" for a decision maker. The bag contains a combination of problem solving techniques and tools that the decision maker can pull out and use as he sees fit. The tools can range from data bases to analytic models to expert systems, depending on the purpose of the DSS. The bag also contains the special tools necessary to integrate and manipulate the other tools to provide different solutions to the problem and the ability to compare these solutions. Just as the carpenter might select a coping saw for one cut of his lumber and a rip saw for another, the decision maker might select linear programming as one approach to a problem and then attack the problem with dynamic programming.

DSSs support the decision maker's cognitive processes, as described by Simon, of intelligence, design, and choice [12]. The "intelligence" process, which is the inspection and examination of a problem, is supported by the DSS'

ability to allow the decision maker to explore the problem and its bounds. The decision maker is allowed to examine the data available and then attempts to structure the problem. He can then select the specific tool necessary to attack the problem from all the tools available. This approach allows the decision maker to fit a tool to the problem, not force the problem to fit the tool which so often happens when the solution methodology is selected beforehand. "Design", which is the generation of alternatives, is supported by the DSS' structure which provides a number of ways to attack a problem and should therefore provide a number of alternative solutions. "Choice", which is the selection of the optimal or best alternative available, is supported once again by the DSS structure and the ability of the decision maker to manipulate the tools in order to compare the alternatives. The key point to remember is that DSSs focus on the decision making process and not a specific methodology for making decisions. DSSs are designed to support and augment a decision maker's ability to make informed, effective decisions by providing a wide range of problem solving approaches that the user can apply to the problem as the situation dictates. Finally, it must be realized that DSSs are designed to support a decision maker, not replace him.

Adaptive Design

The design of a system has traditionally been characterized by four system development activities:

1. Requirements analysis;
2. System design;
3. System development;
4. System implementation.

Adaptive design attempts to compress these activities into a single, as short as possible, phase and iterate the phase repeatedly until the system has "adapted" or evolved to address the entire problem [1:23].

The need for adaptive design results from the need for flexibility when developing DSSs. Sprague and Carlson have noted two primary reasons for using the adaptive design methodology when developing a DSS. They are:

> 1. DSS must evolve or grow to reach a "final" design because no one can predict or anticipate in advance what is required.
> 2. The system can never be final; it must change frequently to track changes in the problem, user, and environment because these factors are inherently volatile [2:132].

Hence, just as DSS are structured to provide flexibility in the solution of a problem, the adaptive design process allows the DSS to evolve to meet the changing needs and requirements of its users and operating environment.

Sprague and Carlson have identified four steps in the development of a DSS using the adaptive design methodology:

1. Identification of a small yet critical sub-problem of the decision process under consideration. The user and builder accomplish this step together.

2. Develop a small, usable system the user can begin using immediately. This allows the user to provide immediate feedback to the builder and further "zero in" on the problem.

3. Expand, modify, and fine tune the system in cycles. Each cycle is a combination of the analysis-design-development-implementation cycle of the traditional system compressed in time to produce many small, iterated changes to the system.

4. The system is evaluated constantly. The system is constantly checked to see if it meets the users' needs. If it does not, changes are designed and implemented [2:140].

The concepts above suggest a radical departure in the way we develop information oriented systems. The question now becomes: Why initiate such a radical change?

Why Adaptive Design and DSSs?

The environment in which the DSS is intended for use is the crisis action planning team's work environment. This environment is expected to possess the following characteristics:

1. The environment is expected to produce problems, in the form of mission statements, which are neither routine nor readily quantifiable. Each contingency presented to the

crisis team is expected to be unique in terms of its operational requirements, political considerations, and diplomatic implications. Hence, each contingency will most likely require an individually tailored problem solving approach.

2. The environment is expected to be extremely volatile, with conflicting and changing requirements for resources and political/diplomatic considerations.

3. Time is expected to be the single most critical factor in the planning environment. Once a crisis has been declared and the decision to use a military option has been made, it is essential that planners generate a plan to support the national interests as rapidly as possible. The speed with which a plan is executed may make the difference between success and failure.

4. Users of the DSS are expected to be cautious of using any automated planning aid initially.

5. The DSS is not expected to be self-supporting. External support may be required to modify and maintain the hardware and software.

As noted above, the problems faced by operational planners in crisis situations are neither predictable nor recurring. However, all the missions presented to the planners have the same basic goal: support the national interests. Every mission also requires that planners address the military planning process as outlined in JCS Pub. 1. This process can be summarized by five basic tasks:

1. Select the force;
2. Deploy the force;
3. Employ the force;
4. Support the force;
5. Recover the force.

While planning for these tasks must be accomplished for any military mission, contingency or not, the way in which planners go about accomplishing these tasks may vary greatly. The point being, every planner will attack and solve a problem differently. The decisions made to accomplish the above tasks depend on a great number of factors and combinations of these factors. Additionally, different factors may weigh more heavily in one situation than in another and may force the consideration of widely diverse options. This combination of different problem solving approaches for a given planner, constantly changing priorities for the decision factors, and the non-repetitive nature of the decisions, makes for an extremely ill-structured and volatile problem solving environment.

It is precisely the type of environment described above that DSS and the adaptive design methodology are intended to address. The changing nature of the problems confronting the operational planner and the uniqueness of each situation suggest DSS as a suitable approach to decision aiding. Adaptive design allows the DSS to grow and mature as the needs of the planners change insuring the system won't become obsolete. A DSS will provide decision makers with a

myriad of problem solving tools which can be structured to attack the problem according to the desires of the individual user. Adaptive design insures the planners have the proper tools to attack the problems as they change over time. Perhaps the most significant aspect of the DSS approach is it purposely avoids locking a decision maker into a fixed or dogmatic approach to solving the problem and allows a planner to objectively seek out viable options.

Adaptive Design: Experimentation or Application?

Most of the research currently available on DSS and adaptive design emphasizes the need to change how we develop information systems, specifically through adaptive design. Yet very little is published as to how we should go about it. This thesis was an attempt to define how we should develop decision support systems, using the adaptive design process for military applications. Therefore, this thesis was both an application of existing theory on DSS development and an experiment to determine how best to implement a DSS using the adaptive design methodology.

Chapter III discusses the adaptive design methodology and its application to the crisis force planning problem. Specifically, it addresses the identification of the force

selection decision as the kernel decision process for the crisis force planning problem and the application of the adaptive design process in developing a DSS to support the kernel process.

III. APPLICATION OF ADAPTIVE DESIGN TO THE SPECIAL OPERATIONS FORCES SELECTION PROBLEM

Introduction

Chapter III discusses the application of the adaptive design methodology to the problem of constructing a decision support system for the selection of SOF units during a crisis situation.

Adaptive design requires a root or kernel decision process be selected as the starting point for system development. Once the kernel process is selected, a small operational system is built around it. This system is then used and modified to better define the needs of the users and the organization. As the requirements are identified during use, the system grows to meet the true needs of the user and organization. Eventually, the system will expand to address the full range of decision support needed by the organization for the particular process under consideration. Adaptive design further supports the evolution of the system over time by ensuring that the decision processes are continually assessed and changes in the process are accommodated in the system.

Kernel Selection

The selection of a kernel system was accomplished using two methods: a literature review of military planning doctrine [4,7] and the use of concept mapping.

Concept mapping is an experimental method for selecting the kernel system in the adaptive design process. Concept mapping is a process that captures the major elements of a problem through a graphical representation elicited from the person or people who must make the decision. According to McFarren:

> A concept map is two or more concepts that are linked to each other depicting a meaningful relationship. Concepts are objects or events which are assigned a semantic label. Dog, chair, and raining are all examples of concepts. The linking words are generally verbs, but adjectives, adverbs, prepositions, and sometimes nouns can also link concepts in meaningful ways. When a map is drawn showing relationships, the result is a schematic device that represents a set of concept meanings embedded in a framework of propositions [11:45].

Concept mapping was used to identify the critical components of the force planning process during a contingency situation. Both the literature review and the concept mapping identified the force selection decision as the critical decision in contingency planning. Virtually every subsequent planning decision was influenced by the force selected for the mission. Concept mapping was used again to identify the key elements in the force selection problem itself. The results of the concept mapping are located at Appendix A.

The kernel decision process chosen for this system was the force selection decision of the military planning process summarized in Chapter II. This process was chosen for four reasons. First, regardless of the concept map or reference used, the first decision faced by planners in a

contingency situation is the force selection decision. Since all other planning decisions hinge on this decision, it is essential that the force be selected quickly and correctly. Second, the selection of the proper force for a given mission is absolutely critical to the success of any military mission. Units assigned a mission for which they do not have the appropriate training or equipment are not likely to complete their mission successfully. Third, the United States has a limited number of Special Operations Forces. These represent a significant portion of the U.S. non-nuclear strategic assets and must be carefully husbanded to ensure they are not wasted on missions for which they are not suited. Finally, very little work has been done in the area of providing decision support to decision makers on how to select the most appropriate force in a contingency situation.

The Storyboard Process

The next step in the adaptive design process is the creation of storyboards. Storyboards are representations of the computer displays that a user anticipates he will find useful. Each display is a representation of the information the builder anticipates the user will need to make his decisions. They may represent pure data or an access to a model or program that the user can execute to gain further insights into the problem. The designer then creates the displays with the user. The user is the person who decides

how useful the displays are and whether or not they need modification. As the displays are developed and refined by the user and designer a 'true' definition of system requirements begins to emerge. The display becomes tailored to answer the questions posed by the user, and is not driven by questions the builder asks.

The storyboard for this DSS began by trying to identify the major types of information a planner might seek when deciding which unit to select for a mission. The relationships identified during concept mapping and research into the planning process served as the guiding force in developing the storyboards. Ideally, the storyboards should have been developed with the user and builder sitting side by side. However, given the separation between the user and researcher, sample screens were constructed and sent to potential users for comment. The comments were then analyzed and the screens were modified as necessary. Appendix B contains the initial storyboards used in the development of PLANNER.

The storyboarding process allowed further refinement and definition of the information required by a planner in the force selection process. Specifically, it identified the need for:

1. A system that allowed inputs to mathematical models to calculate distances to targets, rough cut deployment estimates, and time to target calculations, as well as the

ability to rapidly modify or increase an existing or planned model base to meet future requirements;

2. A system that allowed the viewing of data relating to the SOF units and the ability to rapidly modify and collate such data;

3. A system to examine and sort the inherent characteristics of each SOF unit to determine which unit is the most capable of performing the mission;

4. The need to keep the system flexible and "user friendly" enough for it to be modified by the users as their needs change.

The next step in the development of the DSS was to implement the functions identified via the storyboarding process on the computer system. Prior to the development it was necessary to select the computer software for use in implementation.

Software Selection

Software selection was driven by two factors: compatibility with IBM PCs and the ability of the individual packages to interface with one another. These requirements were levied by the potential users at USSOCOM. Based on the requirements identified during the storyboard process it was decided to use a spreadsheet program for the mathematical modeling, a relational data base for the data structuring and management, and an expert system to assist the decision maker in analyzing the mission requirements. While each

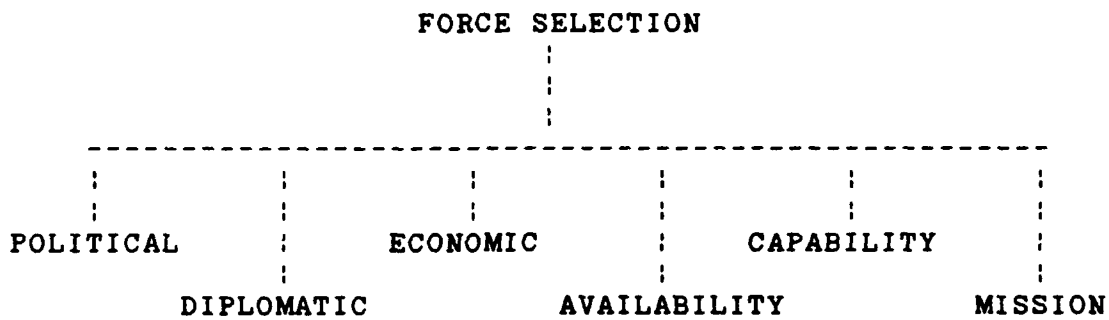
type of software mentioned above has several candidates which are IBM compatible, the deciding factor in the selection became the ability of the separate programs to interface with one another. This narrowed the field of consideration greatly. The systems chosen were all manufactured by the same company, Paperback Software Inc. The systems chosen were: VP Planner Plus, a spreadsheet program that is compatible with Lotus 1-2-3; VPInfo, a relational data base that is compatible with dBASE II,III, and III+; and VP Expert, an expert system development tool that is compatible with all of the packages mentioned above. The total cost of the three packages was $182.00.

All three packages performed very well for the researcher during the development of PLANNER. During the development of the system the documentation and on-line help facilities proved to be excellent. The interface between the systems was outstanding with no problems being encountered when data was passed between programs.

Kernel Implementation

Implementation of the kernel required that the decision processes identified earlier be somehow quantified for use in the computer based decision aid. The force selection problem was reduced to a functional relationship around which the initial version of the DSS was designed. It became apparent that as a minimum the force selection problem was a function of at least six elements. The

functional relationship is shown in Figure 2. This structure was further analyzed to identify the constituents military planners could reasonably be expected to consider in their force selection decision.



FORCE SELECTION = function (POLITICAL CONSIDERATIONS, DIPLOMATIC IMPLICATIONS, ECONOMIC CONSEQUENCES, MISSION, UNIT AVAILABILITY, UNIT CAPABILITY)

FIGURE 2. Force Selection Function

The political, diplomatic, and economic components of the force selection process would most likely be defined by policy makers at high levels within the civilian government. Their assessment and decisions regarding these factors would be included in the decision to use military force and would be transmitted to the military planners in the form of orders to execute a military option. The military policy makers would then consider the problem as transmitted by the guidance and limitations stated in the order. After analyzing the order they would decide upon the appropriate mission to execute in order to support the national interests. The planners would then receive the order to

execute a specific mission and begin the military planning process to accomplish the mission. The unit to perform the mission would be selected based primarily on its ability to accomplish the assigned mission and its availability for employment within the specified time frame. The focus of the military planner in the unit selection decision was recognized as the identification of units capable of and available to perform the mission. Therefore, the kernel implementation focused on determining a unit's capability to perform a given mission and its availability to meet the time constraints for employment.

The kernel was implemented in three phases: a data base phase, a model base phase, and an expert system phase. The resultant system was designated PLANNER Ver.0. The system and its components are described in Chapter IV.

System Evaluation

Evaluation is a key element in the adaptive design process. The success of the process revolves around the ability to continually modify the system based on the user's needs and experiences. PLANNER Ver.0 has undergone only the beginnings of the evaluation process. Users, former planners now students at AFIT, were used to evaluate the system and their recommendations for improvement have been included where possible. Users at the operational commands have not been able to use PLANNER because of funding and travel constraints. However, the concept of the system as

well as the demonstration that such a system can be fielded on a micro-computer have been well received. Further evaluation by the operational commands is necessary to verify PLANNER's conceptual validity and to improve the decision support algorithms embedded in the system. Appendix D addresses some possible evaluation criteria based on Sprague & Carlson's methodology [2:157-172].

Chapter IV discusses PLANNER's use and construction. Appendix C expands on Chapter IV and provides User's and Maintenance manuals for the system.

IV. IMPLEMENTATION OF THE KERNEL SYSTEM

Introduction

This chapter discusses the kernel system resulting from the adaptive design process as applied in Chapter III. The system was implemented in three phases: the model base or spreadsheet phase, the data base phase, and the expert system phase. Each phase of the development resulted in the construction of a component of the system which, when integrated with the other components, formed Version 0 of the kernel decision support system known as PLANNER. This chapter discusses the components of PLANNER and provides a general description of the systems functions.

Appendix C serves as both a User's Manual and Maintenance Manual. It contains the actual computer coding and information necessary to operate the kernel system.

The Model Base Phase

This phase of implementation analyzed the requirements for the system, as elicited by the storyboarding and concept mapping processes, in order to identify the models relevant to the decision process. The purpose of the model base is to support the decision maker by performing the time consuming and tedious calculations the planner must make during crisis planning. By relieving the planner of these burdens the planner is free to concentrate on the force selection problem confronting him.

Two areas were identified as requiring model support. The first was the calculation of the the distance from each unit's current position to the target area for every unit in the data base. The second was the calculation of the time to target for each unit in the data base.

Both models were executed by performing calculations using the macro programming facilities of the spreadsheet. The distance to target for each unit was calculated using the Great Circle distance equation. Each time PLANNER is used, the operator must input the target's longitude and latitude into the spreadsheet. The spreadsheet was programmed to retrieve the SOF and SPECIAL data base relations, extract the longitude and latitude of each unit, and compute the distance to the target using the Great Circle distance equation.

Upon completion of the distance calculation PLANNER calculates the time to target for each unit. The time to target for each unit is identified as an additive function of the following elements:

1. The time required for a unit to become available for the mission. This might be the time necessary to recall the unit's personnel or it might be the minimum time necessary for a unit to disengage from or complete a mission in progress.

2. The time required for a unit to plan for a mission once it receives its orders.

3. The time necessary for a unit to rehearse for a mission once it completes its planning.

4. The time required for a unit to be transported from its current location to the target area.

The time for a unit to become available for a mission is a function of its current mission status. PLANNER requires that this entry be updated whenever a unit changes its mission. Planning time and rehearsal times for each unit are assumed to be doctrinally established. While they are highly sensitive to the complexity of the mission it was assumed that an average time for both could be acquired by interviewing the planning staffs of the units themselves. The time of transit was modeled by dividing the distance to the target by a 400 knot block speed. It was assumed that a C-141 aircraft flying non-stop, using mid-air refueling if necessary, would deliver the unit to the target area.

PLANNER calculates the transit time and adds the three other times described above to transit time to obtain the times to target for each unit. The data relations are then updated and saved reflecting the new target information for later use.

These actions complete the model base of PLANNER Ver. 0's implementation. Chapter V includes possible extensions and improvements to the model base.

The Data Base Phase

The data base phase resulted in the construction of the data base component of the DSS. The purpose of the data base is to support all the other operations in the DSS by supplying current data reflecting the status of the units allocated to the planners. Its construction was based on the information requirements that were identified in the concept mapping and storyboarding processes and the operations modeled in the spreadsheet and expert systems phases. By analyzing the requirements identification process and model structure, four key data base relations were identified and constructed: SOF, MISSION, COUNTRY, and SPECIAL.

SOF.DBF. SOF.DBF is a relation that captures the current state of nature for the special operations units under consideration for a mission. The SOF data base consists of seven records, one for each unit used in the kernel system. Each record consists of fourteen fields that represent the current status of each unit in the data base. Each of the fields is described below.

NAME: This field is an alpha-numeric representation of the unit designation. It names the unit that the record describes.

LAT: This field contains the current latitude of the unit. It is expressed in decimal form with east latitudes expressed as negatives.

LON: This field contains the current longitude of the unit. It is expressed in decimal form with south longitudes being expressed as negatives.

DISTTGT: This field contains the great circle distance from the unit's current location to the crisis target area. This distance is calculated by the model base whenever PLANNER is used.

TAVAIL: This field contains the earliest time a unit will be available for a mission. This field can represent the minimum recall time for a unit or the time necessary to recover a unit from another mission before employing it on the current mission. This time would be provided by the commander of each unit. It would change whenever a unit's status changed. This entry might require daily updating.

PTIME: This field contains the minimum time necessary for a unit to plan a mission once it receives its orders. This time would be supplied by the commander of each unit.

RTIME: This field contains the minimum time necessary for a unit to rehearse its plan for a given mission. This time would be supplied by the commander of each unit.

TRTIME: This field contains the minimum transit time from the unit's current location to the target area in C-141 aircraft. This assumes flying the great circle route, a block speed of 400 knots, and mid-air refueling if

necessary. This field is updated by the model base whenever PLANNER is used.

TTGT: This field contains the minimum time to target for the unit as calculated by the model base. It is the summation of TAVAIL, PTIME, RTIME, and TRTIME. It is updated whenever PLANNER is used.

UNSIZE: This field contains the current deployable strength of the unit.

SUNIT: This field contains the number of sub-units currently operating with the parent unit.

TGTAC: This field represents the physical area the unit could be expected to control on a mission.

TGTPC: This field represents the number of friendly people the unit would be capable of controlling and protecting on a mission.

GARRISON: This field denotes the unit's home station.

MISSION.DBF. The MISSION.DBF relation represents the current mission priorities of each unit in the data base. The purpose of this relation is to recognize the doctrinal mission capabilities of the SOF units available to a command. There are seven records in this sample file, one for each unit represented in the kernel system. Each record consists of six fields which are described below.

NAME: This field is an alpha-numeric representation of the unit designation. It names the unit

that the record describes. It must be the same as the name field in the SOF relation.

MSN1: This field contains the unit's first priority mission.

MSN2: This field contains the unit's second priority mission.

MSN3: This field contains the unit's third priority mission.

MSN4: This field contains the unit's fourth priority mission.

MSN5: This field contains the unit's fifth priority mission.

COUNTRY.DBF. The COUNTRY.DBF relation represents the current targeting priorities of each unit in the data base. The purpose of this relation is to acknowledge the geographical targeting priorities for some of the SOF units available to a command. As with MISSION.DBF, there are seven records in this file, one for each unit represented in the kernel system. Each record consists of six fields which are described below.

NAME: This field is an alpha-numeric representation of the unit designation. It names the unit that the record describes. It is the same as the name field in the SOF and MISSION relations.

CTRY1: This field contains the unit's first priority target country.

CTRY2: This field contains the unit's second priority target country.

CTRY3: This field contains the unit's third priority target country.

CTRY4: This field contains the unit's fourth priority target country.

CTRY5: This field contains the unit's fifth priority target country.

SPECIAL.DBF. This relation is a combination of the above relations. Its purpose is to serve as the knowledge base for the expert system when in use. SPECIAL.DBF consists of seven records, one for each unit represented in the kernel system. Each record consists of twenty fields. Fields one through fourteen are the same as the fields of SOF.DBF. Fields fifteen through seventeen are the same as the MSN1,MSN2, and MSN3 fields of MISSION.DBF. Fields eighteen through twenty are the same as the CTRY1,CTRY2,and CTRY3 fields of COUNTRY.DBF.

The construction and testing of these relations completed the data base phase of PLANNER Ver.0 's implementation. Chapter V discusses improvements and recommendations for further development.

Expert System Phase

The expert system component of PLANNER was developed to help the mission planner rapidly classify the units in the data base based on their capability and availability to

perform the mission. The expert system is accessed via the spreadsheet once the data base has been updated. The mission planner is queried by the expert system to determine the parameters for unit selection. During consultation the expert system asks the user the following questions to establish the parameters of the mission:

1. What is the mission?
2. What is the target country?
3. What is the desired time to target?
4. What is the size of the target, in SQ.KM.?
5. How many friendlies are in the target area?

PLANNERS's expert system compares the user inputs to the unit characteristics stored in SPECIAL.DBF and classifies each unit into one of twelve categories of availability/capability and a thirteenth category of non-available/non-capable. The expert system recommends the units for selection to the mission planner based on their classification. The classification and selection criteria are discussed in Appendix C. Final selection of the unit for the mission is accomplished by the mission planner based on his own experience and knowledge of the mission and the recommendations of PLANNER.

Construction of the expert system code and verification of the algorithm by experimental use completed the expert system development phase. Chapter V discusses possible improvements and recommendations for further development.

PLANNER: System Use

The three components of the implementation phases were then integrated to form Ver. 0 of PLANNER. The spreadsheet serves as the entry point and controller of the system The mission planner activates the system by starting the spreadsheet program in the PLANNER directory of the micro-computer. Upon opening the file the mission planner is presented a message describing the system and its function. From that point instructions are presented on the screen, via the macro programming facilities, that lead the user through a consultation.

The first action a user must take is to initiate the 'ALT-Z' macro. This macro requires the user to input the target country and location, in latitude-longitude form, into the data base. Once the user has input the information in response to the on-screen prompts, the model base pulls the data base relations SOF and SPECIAL into the spreadsheet and updates the unit time to target information and saves the changes to the data base as described in model base development above. At this point the user is presented with three choices: exit to the expert system, browse the updated data base, or quit the system.

The macro 'ALT-E' allows the mission planner to exit to the expert system to obtain a recommendation on unit selection. The expert system is accessed while the spreadsheet runs in the background. When the user exits to the expert system, a set of instructions is printed

providing instructions on how to use the expert system and return to the spreadsheet. The user is then free to consult with the expert system. Once the user has completed the expert system consultation a list of recommended units is printed and the user can return to the spreadsheet to complete the session.

The "ALT-B" macro allows the mission planner to browse the data base once it has been updated by the model base. The display presented was created to show the flexibility of the data base access feature of PLANNER. The items displayed in Ver. 0 are the relations SOF, MISSION, and COUNTRY and a data table built from SOF that reflects the transportation time to the target for aircraft other than the C-141. The displays can be modified to suit the user's need with simple revisions to the macro codes or by using the data external functions provided by the spreadsheet's permanent menu.

The "ALT-Q" macro allows the mission planner to quit PLANNER in three different ways. When ALT-Q is executed a menu presenting three choices is displayed at the bottom of the spreadsheet screen. The first choice, PRINT, prints the data browse display, clears the work area, saves the spreadsheet, and terminates the session returning the user to the system. The second choice, RESTART, clears the work area and takes the user to the top of the spreadsheet in order to restart the consultation. The last choice, QUIT,

clears the work area, saves the spreadsheet, and terminates the session returning the user to the system.

These macros need not be executed in any specified order with the exception of updating the data base via "ALT-Z" which must be executed first. In keeping with the concept of not locking a decision maker into a single decision methodology, the system is designed to provide the user with the flexibility to move between the separate components of the system as necessary to support his way of making decisions.

The system, in its current form, supports only a small portion of the force selection problem. However, it must be remembered that the adaptive design methodology emphasizes the fielding of a small first-cut system that can be used and iteratively improved. PLANNER Ver. 0 is the first iteration of the adaptive design cycle.

There is great room for improvement in this system. Chapter V discusses recommended improvements and expansions for PLANNER. Additionally, Chapter V discusses the application of the adaptive design methodology and its implementation to the force selection problem.

V. RECOMMENDATIONS AND CONCLUSIONS

Introduction

This chapter discusses recommendations and conclusions for two areas. First, recommended improvements and extensions of PLANNER Ver. 0 are discussed. Second, recommendations and conclusions relating to the adaptive design methodology as applied to the SOF force selection decision support system are examined.

PLANNER Ver. 0 Enhancements

Recommended improvements and enhancements for PLANNER Ver. 0 were documented during the design and implementation phases through the use of a "hook book". A "hook book" is a collection of thoughts and ideas relating to system improvements and enhancements collected by the builder and user during the evolution of the DSS. This collection of improvements are those that are not implemented in the system due to technological barriers, cost, or time constraints. The "hook book" also allows the adaptive design process, which suggests rapid iterations of small improvements to the system, to proceed without the builder and users losing their ideas that cannot be immediately incorporated into the system.

"Hook books" can be implemented in several ways. The two most common ways are to embed the "hook book" capability into the DSS itself or to manually maintain a file of ideas.

While the first method is preferable because it allows the users and builders to input the ideas or thoughts as they use the system, the builder of PLANNER chose the manual system based on its ease of implementation and the fact that users are not always at the computer when an idea is generated.

The items identified in the following paragraphs are items that the builder perceives as necessary to the productive development of PLANNER in the future. These items are not listed in any priority order because they have not been fully discussed with the users. For a more complete listing of these "hook book" items see Appendix E.

General System Expansion

PLANNER is in its infancy at this stage of development and there is great room for expansion in all components of the system.

PLANNER needs an automated "hook book" embedded in the system itself. The current method of note taking and filing is cumbersome and extremely tedious to organize. The implementation of the automated "hook book" could greatly ease the burden of managing the evolution of the system.

The current screen displays provided by PLANNER are adequate to convey the necessary information to the users but can be distracting as the system executes. Therefore this "dialogue" component requires attention, starting with the use of more menus to drive PLANNER's operation.

The initial screen of PLANNER requires a user to input the target longitude and latitude into the model base before PLANNER can begin operating. It appears that a routine or program that helps a user determine the exact latitude and longitude of the target for input to the system would be useful. An examination of the various commercial and/or military mapping and location finding programs for integration into PLANNER would be useful. This capability would allow the user to forgo the use of paperbound atlases and simply make the user's job easier.

The "dialogue" is critical to its success. Without user acceptance of the dialogue the system is not likely to gain acceptance nor contribute to the mission.

Model Base Enhancements

Several possible improvements in the model base have been identified. Some of these enhancements would require models and simulations to be designed and developed. Others would require the interfacing of PLANNER and existing models.

Distance Model Improvements. PLANNER could benefit from a model that provides a more realistic time to target calculation. The current model is constrained by calculations of the Great Circle route distances. This method ignores the problems of over-flying certain countries and the need to stop, in some cases, for fuel and maintenance. A model that accounts for these considerations in its calculations would relieve the mission planner from

accounting for these differences manually. An examination of the interfacing possibilities of existing force closure and deployment models with PLANNER would prove beneficial

Applications to MAPP. While PLANNER has been initially designed to address the special operations force selection, it could also be extended to conventional forces as well. The development of interfaces to the modeling and simulation tools currently available to the CINCs might provide a great deal of utility to the mission planners as they assess different courses of action.

PLANNER could be used as a front end processor for models, like SOTACA, to recommend forces for use in various courses of action based on the missions assigned and the availability of the units in the conventional force structure. PLANNER could be interfaced with the unit planning files available to the CINC's mission planners and used to sort and evaluate the capabilities and availabilities. The system could then provide a set of recommended force packages for the mission planners' consideration. This application would require considerable study in the areas of conventional mission taskings and prioritizations as well as a vast increase in the size of PLANNER's basic structure to handle the larger number of conventional units. An examination of PLANNER for use in these areas will be required in the future.

Multiple Criteria Decision Making (MCDM). The force selection decision process represented in Figure 2 could

also be considered a problem in MCDM. The process requires a great deal of subjective as well as objective judgments on the part of the mission planning team. MCDM techniques address the aggregation of such diverse requirements to obtain a more understandable form of the problem and its answers. An examination of MCDM techniques and their application to PLANNER should be conducted in future developments of PLANNER.

Data Base Expansions

Data base expansions to improve PLANNER's capability have been identified throughout the development of the system.

During use by surrogate users it was noted that PLANNER's data base aggregated the following model variables into averages or expected values: 1) mission planning and rehearsal times; 2) the area a unit was capable of controlling; and 3) the number of friendlies a unit was capable of controlling. In reality these times are probably more a function of the mission and area of operations. If estimates of time to target and unit capability can be made more accurate based on the mission scenario then an examination of creating data files based on the mission, which reflect the actual time required for planning and the true operational capabilities for each type of mission, would prove beneficial. These are judgment processes that deserve their own support as the system evolves.

Currently, only data files representing a small portion of the information required by a planner to make a decision exist. These files need to be expanded to include information reflecting the current manning levels, training status and history, and equipment status of each unit in the data base. Files such as these would provide a better view of the units' capability to perform a given mission. An examination of how to structure and implement these types of files would provide a significant improvement over the current version of PLANNER. This examination should begin with an assessment of the current data structures used in the World Wide Military Command and Control System (WWMCCS) and their compatibility with PLANNER.

With a system such as PLANNER it is critical to establish a central control on the data base. Contamination of the data base by unauthorized personnel could result in disastrous consequences for the units employed on a mission. The concept of maintaining a centralized data base for decentralized DSS applications must be addressed. This data base would be maintained and protected by a systems manager. Users would not be able to modify the data base without the assistance of the data base manager.

Expert System Enhancements

The expert system of PLANNER has several areas that have been identified, by the researcher and the surrogate users, as requiring improvement. The system as it exists in

Version 0 is a demonstration of how such a system can be integrated with other tools to form a decision support system and as such is extremely narrow in its scope. The expert system should be expanded to capture more elements of the mission planning process to provide a better recommendation to its users. The system should be expanded to consider such items as: 1)the enemy threat in the objective area; 2)the current training status of the units under consideration; 3)special equipment or training requirements; and 4)the political, diplomatic, and economic implications of using certain types of forces. This effort would not be trivial. It would require a great deal of coordination among many government agencies and some very hard decisions to be made by those responsible for joint special operations doctrine. Eventually, this expert system could evolve into a repository for special operations doctrine that could provide guidance to the mission planners at the unified commands. While the author does not and will never advocate the use of expert systems or any other automated system to <u>make</u> planning decisions, he does feel such a system could provide useful and consistent guidance to mission planners over the long run. In concert with the idea of using the expert system as a doctrinal planning guide, the expert system could also be a repository of the historical aspects of special operations. It would in effect become a living library of after-action reports upon which all special operations planners could draw. The

lessons learned from each operation could be encoded and stored in the knowledge base. When a planner used the system it would search the knowledge base to determine if any past operations were similar to the one under consideration. The expert system could use this information to make its recommendations and notify the planner of the historical similarities noted during its search. Once again, this is not a trivial undertaking and would require a great deal of support from the entire special operations community.

System Evaluation

Evaluation is a key component of the adaptive design process and systems development in general. Three components of evaluation must be considered: 1) verification of the system structure; 2) validation of the system approach to the problem; and 3) measuring of the kernel system's effectiveness.

While verification and validation processes have not been fully implemented for PLANNER Ver. 0 because of the geographical separation of the builder and users and funding constraints for travel, some aspects of these processes have been initiated.

Verification of the code for the spreadsheet and expert system was accomplished by the builder during development. Surrogate users were shown how to use the system and sample scenarios were input to test the accuracy of the system's

recommendations and calculations. In short, the kernel system does what it was designed to do.

Validation of PLANNER's approach to supporting the decision maker will take more time and use by planners in the operational command. It must be remembered that PLANNER and its development are iterative. Each version is used, assessed, and improved as rapidly as possible to meet user needs. Therefore validation is not a one time happening, it occurs every time PLANNER is modified.

The effectiveness of the system must also be evaluated. Once again, the only way to accomplish this is to field the system and observe its affects on all aspects of the problem environment, to include: 1) the system itself; 2) the users; 3) the environment; and 4) the decision task. While many measurements of a system's effectiveness may be more qualitative than quantitative, there are some quantitative measures that can be assessed. The first of these measures is time. How much time does the system save the user when compared to the current way of planning? If it takes longer to arrive at the same answers using PLANNER than it does with the old methods, then PLANNER needs to be modified or to be scrapped altogether.

Another measure is system use. The amount of system use is generally accepted as a measure of system acceptance by its users. If planners aren't using the system then it doesn't contribute to the mission and should be modified

until it is accepted by the users or canceled if it does not gain acceptance [13].

The response time and ease of use of the system are two more measures that may reflect the usefulness of the system. If a system takes too long to respond to user inputs, is too difficult to learn, or requires an inordinate amount of time to master, then it becomes counterproductive to the mission and should be modified or canceled.

All of the measures listed above are efficiency oriented and could be captured by a system monitor at the using command through techniques not elaborated upon here. Current research into the effectiveness of decision aids and its measure is limited and generally inconclusive [13]. The issue of measuring effectiveness in military decision aiding is of great concern because of the extremely high stakes military decision makers are faced with, the lives of the soldiers, sailors, and airmen in the field. Many of these measures will have to be developed over time as the military planners use and absorb this automated decision aiding technology. The point of the preceding discussion is to focus the evaluation of the system on the needs of the user relative to his environment and task, in order to produce and evolve usable, effective systems to support the operational planner. Some possible examples of evaluation criteria for decision support systems are located at Appendix D.

Adaptive Design Methodology

In this researcher's view, the adaptive design methodology proved to be an effective methodology for building the kernel SOF unit selection decision support system. The ability to reduce the problem to a manageable size and the flexibility in the development provided by the adaptive design methodology proved invaluable during this research project.

Storyboarding and concept mapping proved to be excellent tools, in this researchers opinion, for eliciting and capturing system's requirements from users. These approaches allowed the user to "see" what he was thinking and comment on the appropriateness of the representations as the system evolved. This approach is radically different from the traditional systems development approach where the user generally sees the end product after the requirements and development phases. The ability of the user to provide the builder with immediate feedback on the system's displays proved beneficial to all involved. While the user was not as closely involved as the builder would have liked, due to distance and funding constraints, the adaptive design methodology appears to be a much less adversarial way of developing decision aids and insures the user and the builder are on the same sheet of music during the development process.

As stated above, the storyboarding process proved excellent at capturing requirements. However, the

implementation of the initial storyboards as first constructed proved beyond this researcher's capabilities. The process behind the storyboard was captured. Yet the displays initially envisioned simply could not be generated given the current hardware and software available and the researcher's inexperience in computer programming. Builders and users must be careful not to expect too much from the initial system they develop. This clearly reinforces the idea behind adaptive design of starting small and building the system's capabilities over time.

Builder's Perspective

The use of off-the-shelf software proved to be an extremely easy way to build the system. Most of today's software packages are either very user friendly or evolving to be so. If an analyst or planner is sufficiently knowledgeable about the problem at hand, it is the researcher's opinion that there are probably several software packages available to build an effective and extensive decision support system using the adaptive design methodology. As an example, the researcher had never used a spreadsheet or data base program prior to September 1987 and had no experience in the use of expert systems until December 1987. Yet given the researcher's familiarity with military planning and the knowledge acquired learning about the system's components, the researcher was able to build PLANNER in approximately 120 man hours.

To provide a truly functional link between the system builder and the user it is essential that they be colocated and available to one another at all times. The separation of the user and the builder during this research clearly slowed the development and implementation of PLANNER.

Perhaps the most interesting conclusion drawn from this research is the realization that a great deal of decision support required by operational planners lies at their fingertips. The expertise in planning lies with the operational staff. If these planners can be provided the user friendly hardware and software available today they can construct a large portion of the decision aids they need. In effect, this combines the user and builder as defined in Sprague and Carlson's BUILDING EFFECTIVE DECISION SUPPORT SYSTEMS [2:25-26].

Technical consultation will still be required to provide mission planners with help in the development of some complex or sophisticated system's interfaces. Additionally, support will be required to help the planners develop their data base relations as well as help in structuring components such as expert systems.

This research indicates that, for the most part, decision support can be cheaply, easily, and conveniently created by those who need it. This conclusion opens up a new area of research in regard to PLANNER and systems like it. The conclusion above essentially recommends the adoption of end-user-computing/development of military

decision aids. This raises some extremely difficult questions that the commands will have to address, some of which follow:

1. Are the users trained well enough to build the systems they need?

2. Who will maintain the system after its user has departed?

3. How well can these customized systems interface?

4. Who is responsible for documenting the systems?

5. Can the command afford to train its users to some common standard considering manning shortages and funding?

These are some of the difficult questions that end-user-computing raises. It is the researcher's opinion that these questions can only be answered by experimentation in the field.

Recommendations

This research resulted in the identification of four recommendations. First, USSOCOM should bring PLANNER to its users and continue its evolution using the adaptive design methodology. While the system is neither complete nor fully operational it provides a start point for the creation of automated decision aids in USSOCOM. Second, USSOCOM should initiate a pilot program to examine the feasibility of using the adaptive design methodology to develop its own command and control decision aiding systems. These systems would be developed under the guidance of Commander, USSOCOM and

distributed to the operational commands for use in special operations planning. This centralized development would insure the dissemination of a coherent special operations planning doctrine to all theaters and commands while partially fulfilling USSOCOM's mission charter to establish and distribute joint special operations doctrine. The adaptive design methodology would also allow the using commands to adapt the system to their own needs based on their unique mission or geographical requirements. Third, the Unified and Specified commands participating in the Modern Aids to Planning Program should examine the use of PLANNER, or systems like it, to provide front end support to their simulation efforts. A future version of PLANNER could be used to help mission planners select the most qualified and available units for use in a contingency and recommend force packages to be evaluated in course of action analyses using the current simulations, such as SOTACA. Fourth, USSOCOM, as well as the other Unified and Specified commands, should examine the way they develop and field decision aids. It is the researcher's contention that much of the decision support required by staffs can be developed in-house given the time and money currently allocated to civilian contractors. It may be argued that in the time of shrinking budgets and reductions in manning that operational commands must resort to the use of contractors to develop decision aids. This researcher believes that planning staffs are currently capable of developing their own

decision aids with very little additional expenditure of training and time given today's user-friendly systems and their intimate familiarity with their jobs. While in-house systems may not be as glamorous or as sophisticated as their civilian counterparts, if they are developed by the people who use them you can be sure they accomplish the intended mission, which is, after all, the warrior's concern.

APPENDIX A

CONCEPT MAPPING

The following concept maps represent the initial "cuts" at problem definition. They represent a distillation of the problem through a graphical representation. The first concept map identifies the critical components of unit selection; unit capability to perform the mission and unit availability to perform the mission. The second concept map identifies how all the other constituents of the planning process depend on the selection of a specific unit for the mission.

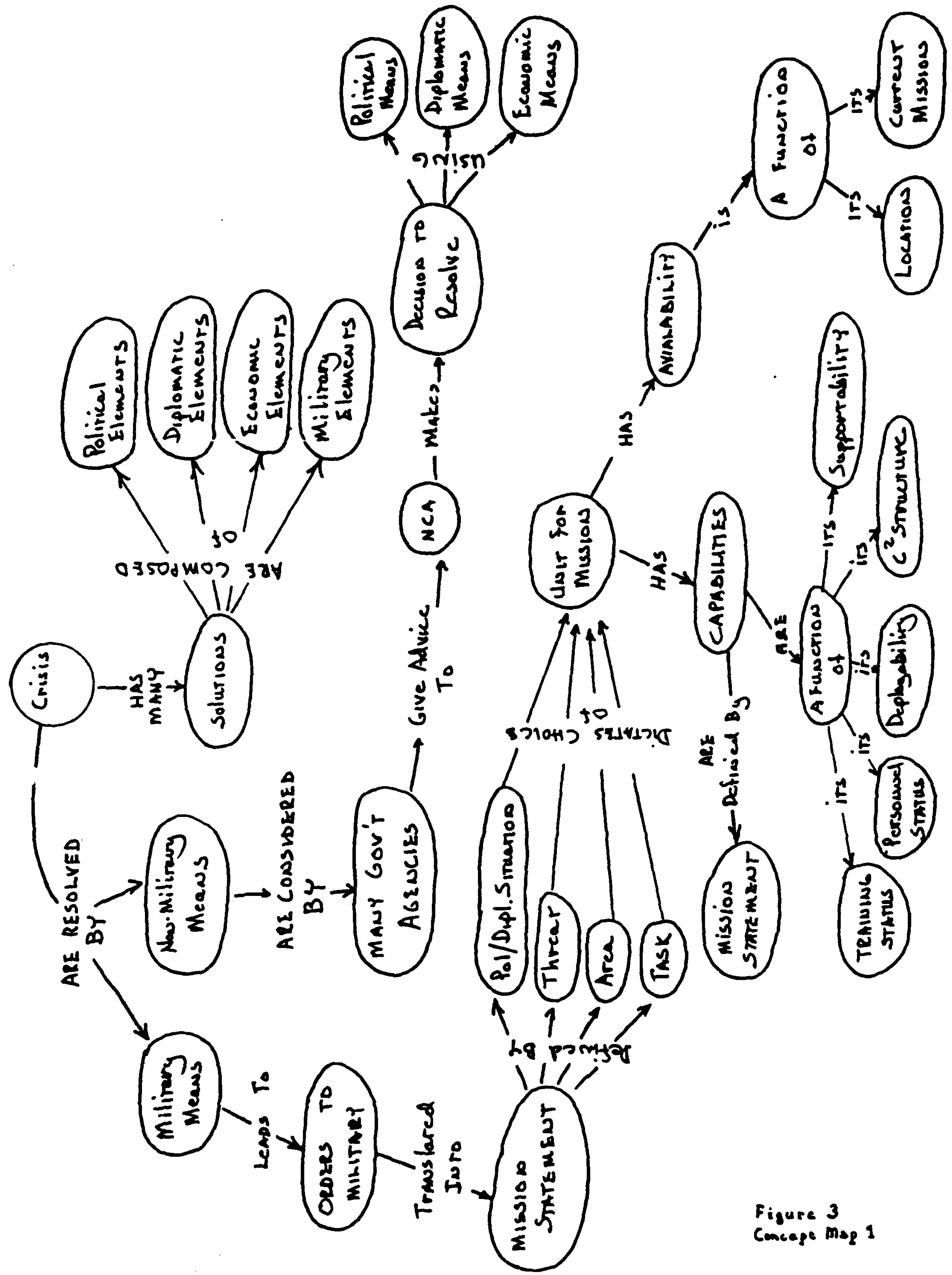


Figure 3
Concept Map 1

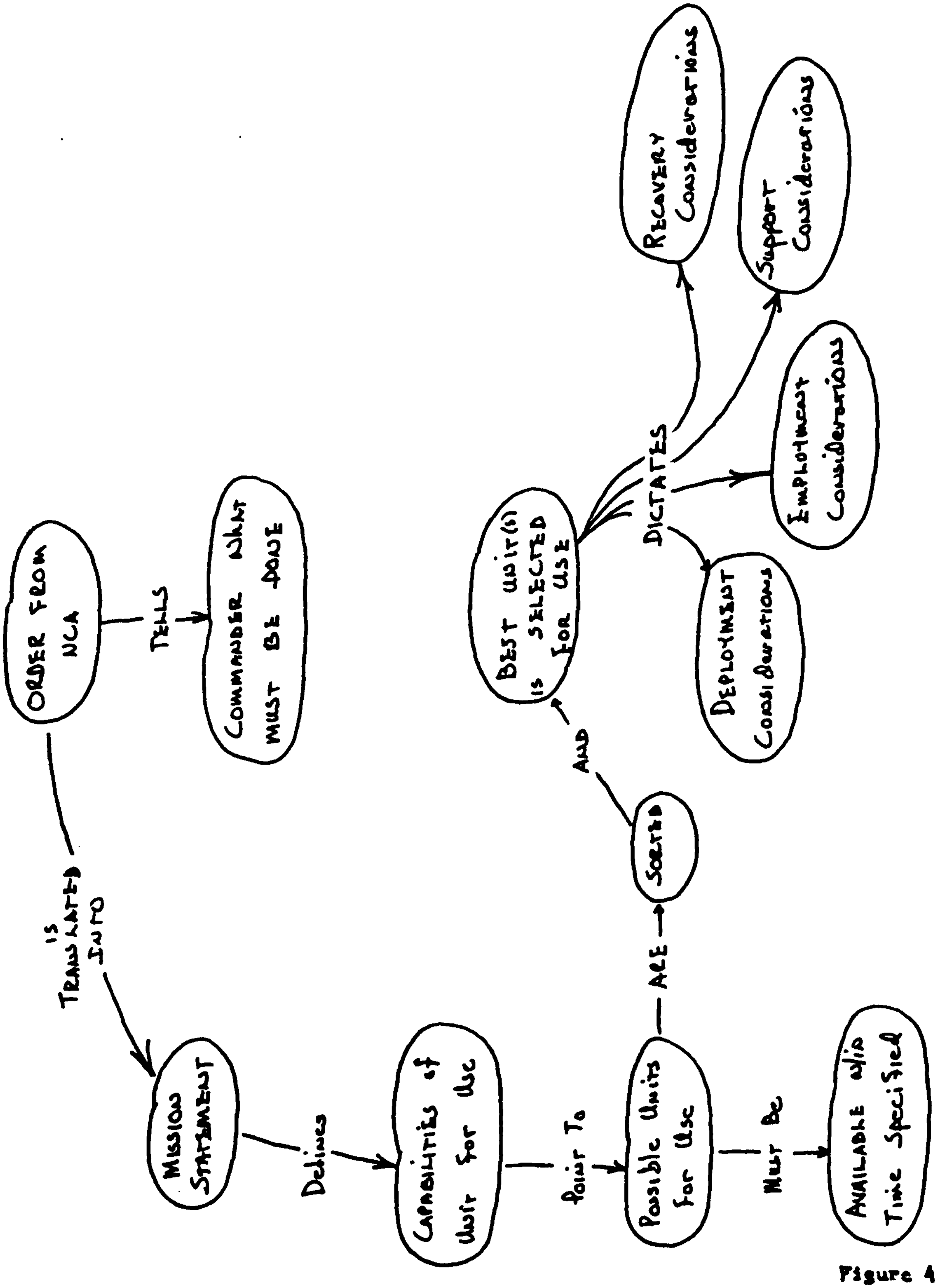


Figure 4
Concept Map2

APPENDIX B

STORYBOARDS

The following story boards were developed as a part of a much larger project that tried to define the needs of a complete command, control, and information system through story boarding. The story boards presented were identified as the basis for the decision support system kernel. The system implemented in PLANNER tries to capture the processes in the background of the representations. PLANNER's first version was not able to incorporate the extensive mapping and windowing facilities envisioned in the story boards. Additionally, PLANNER was designed to be implemented using a micro-computer and the original story boards were created without regard to the host system. Each storyboard is followed by an explanation of its conceptual purpose.

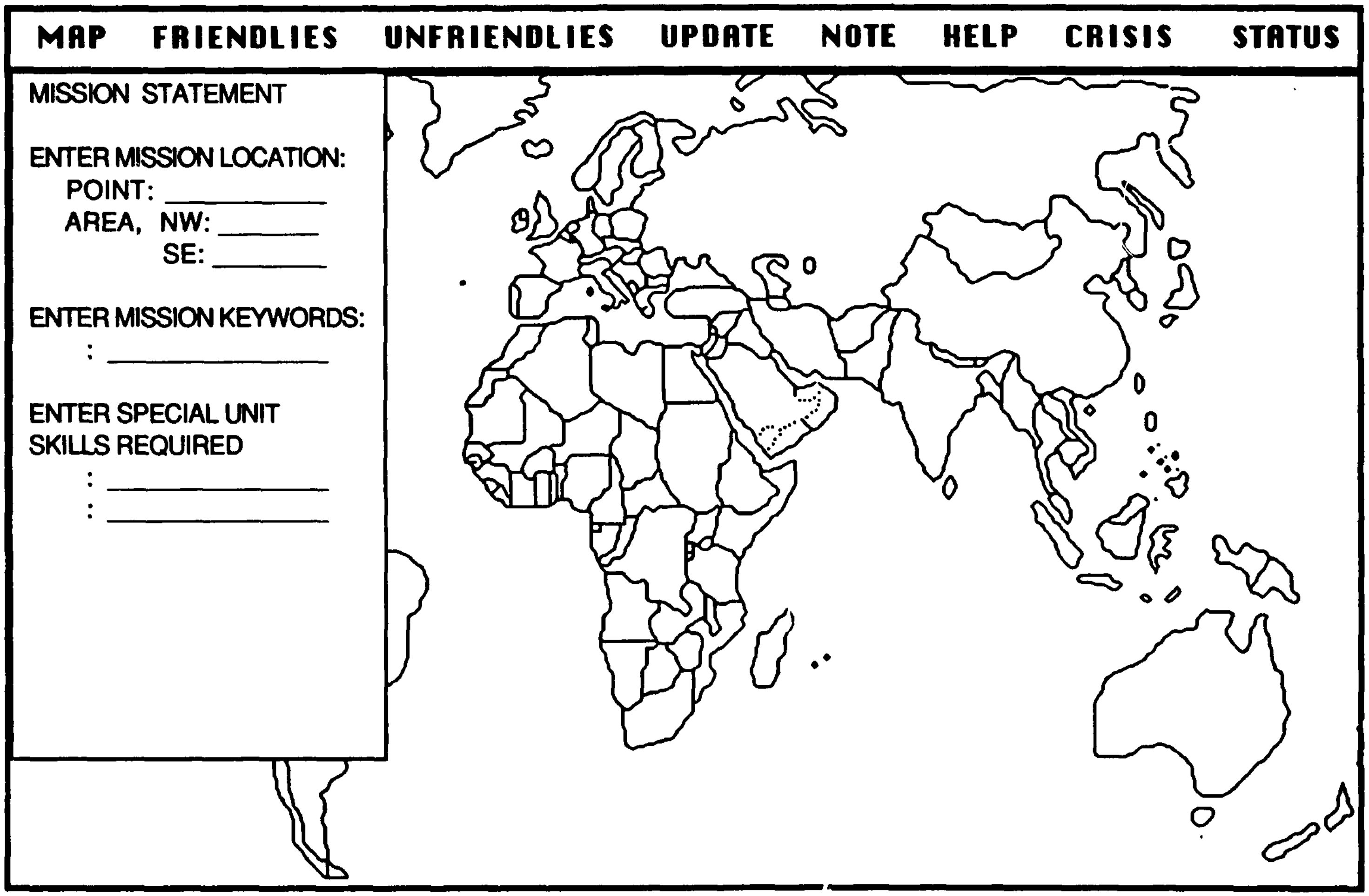


Figure 5 **STORYBOARD 1**

STORYBOARD I

MISSION STATEMENT DISPLAY (ROUTINE)

PURPOSE: GATHERS INFORMATION ABOUT MISSION; COMPARES MISSION REQUIREMENTS TO UNIT CAPABILITIES AND AVAILABILITY; PROVIDES USER WITH LISTING OF AVAILABLE UNITS.

OPTIONS: NONE

NOTE: 1. MISSION INFORMATION IS ENTERED AND STORED, MULTIPLE TARGETS MAY BE ENTERED.

2. KEYWORDS AND SPECIAL SKILLS ARE ENTERED. SYSTEM COMPARES KEYWORDS AND SKILLS (REQUIREMENTS) TO DOCTRINAL OR DEMONSTRATED UNIT CAPABILITIES. THIS LIST OF "CAPABLE" UNITS IS COMPARED WITH UNIT STATUS FILES TO SEE WHICH UNITS ARE AVAILABLE. THIS CREATES THE FORCE AVAILABLE FILE WHICH IS TRANSFERRED TO THE FORCE SELECTION MODULE (NEXT DISPLAY).

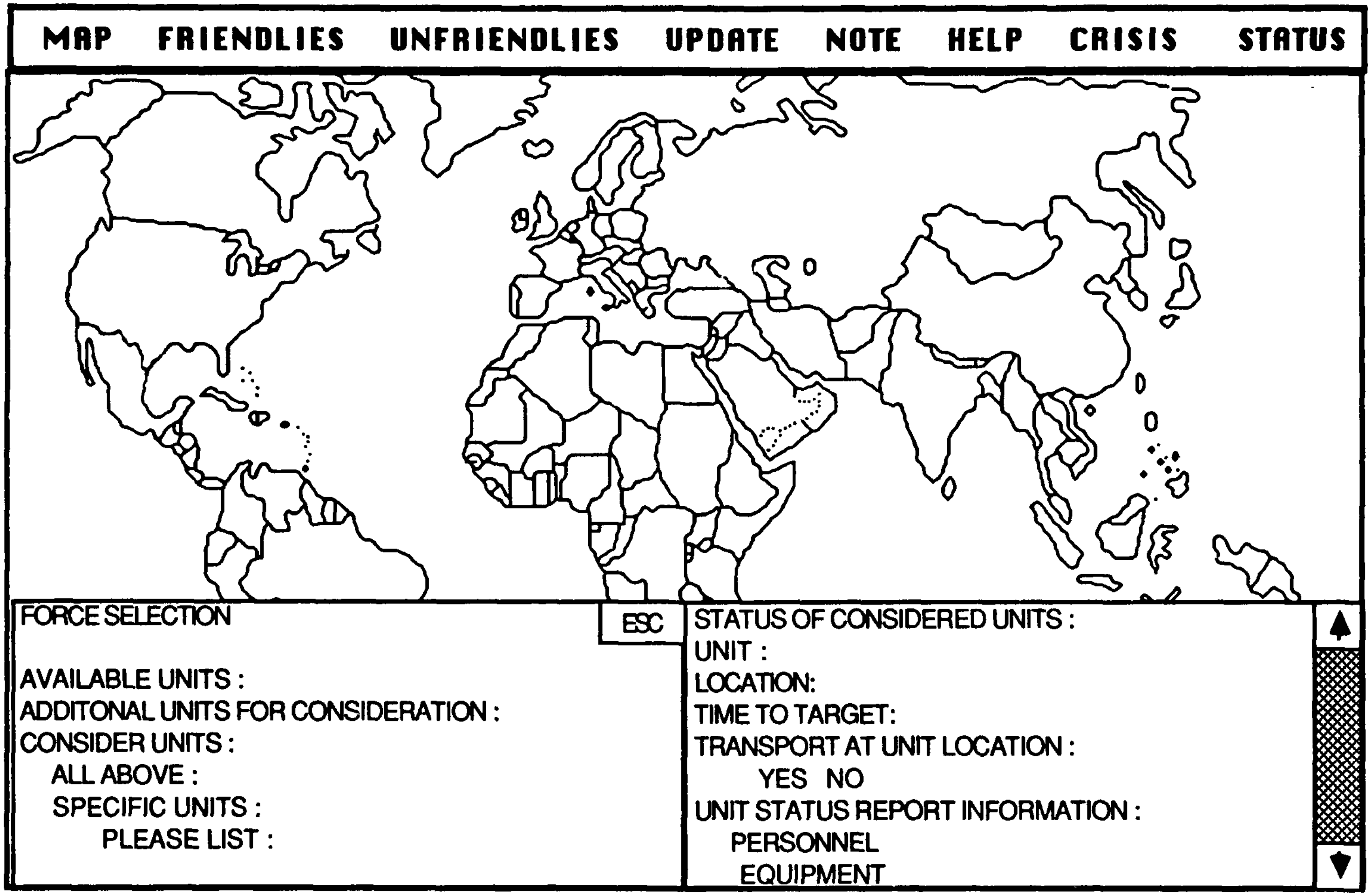


Figure 6 **STORYBOARD 2**

STORYBOARD II

FORCE SELECTION DISPLAY1 (ROUTINE)

PURPOSE: TO ASSIST THE USER IN SELECTING THE BEST AVAILABLE SPECIAL OPERATIONS UNIT FOR THE MISSION.

OPTIONS:
1. AVAILABLE UNITS: FROM MISSION STATEMENT DISPLAY (PREVIOUS STORY BOARD)
2. ADDITIONAL UNITS FOR CONSIDERATION: ALLOWS USER TO ENTER UNITS HE WOULD LIKE CONSIDERED BASED ON PERSONAL KNOWLEDGE OR PREFERENCES.
3. CONSIDERED UNITS:
   - A. ALL ABOVE: ALL UNITS LISTED IN AVAILABLE UNIT AND ADDITIONAL UNIT FILES
   - B. SPECIFIC UNITS: SELECTED BY USER

NOTE: 1. STATUS OF CONSIDERED UNIT DISPLAY ALLOWS USER TO "BROWSE" A DATA BASE CONTAINING INFORMATION ABOUT THOSE UNITS. THE USER MAY DECIDE WHETHER OR NOT TO CONSIDER THE UNITS BASED ON INFORMATION IN THE DISPLAY. ITS PURPOSE IS TO SERVE AS A MEMORY AID.

2. SCROLL BAR WOULD BE AVAILABLE.

3. CONSIDERED UNITS, ONCE DESIGNATED, ARE LOADED INTO THE DECISION MODEL. (SEE NEXT DISPLAY)

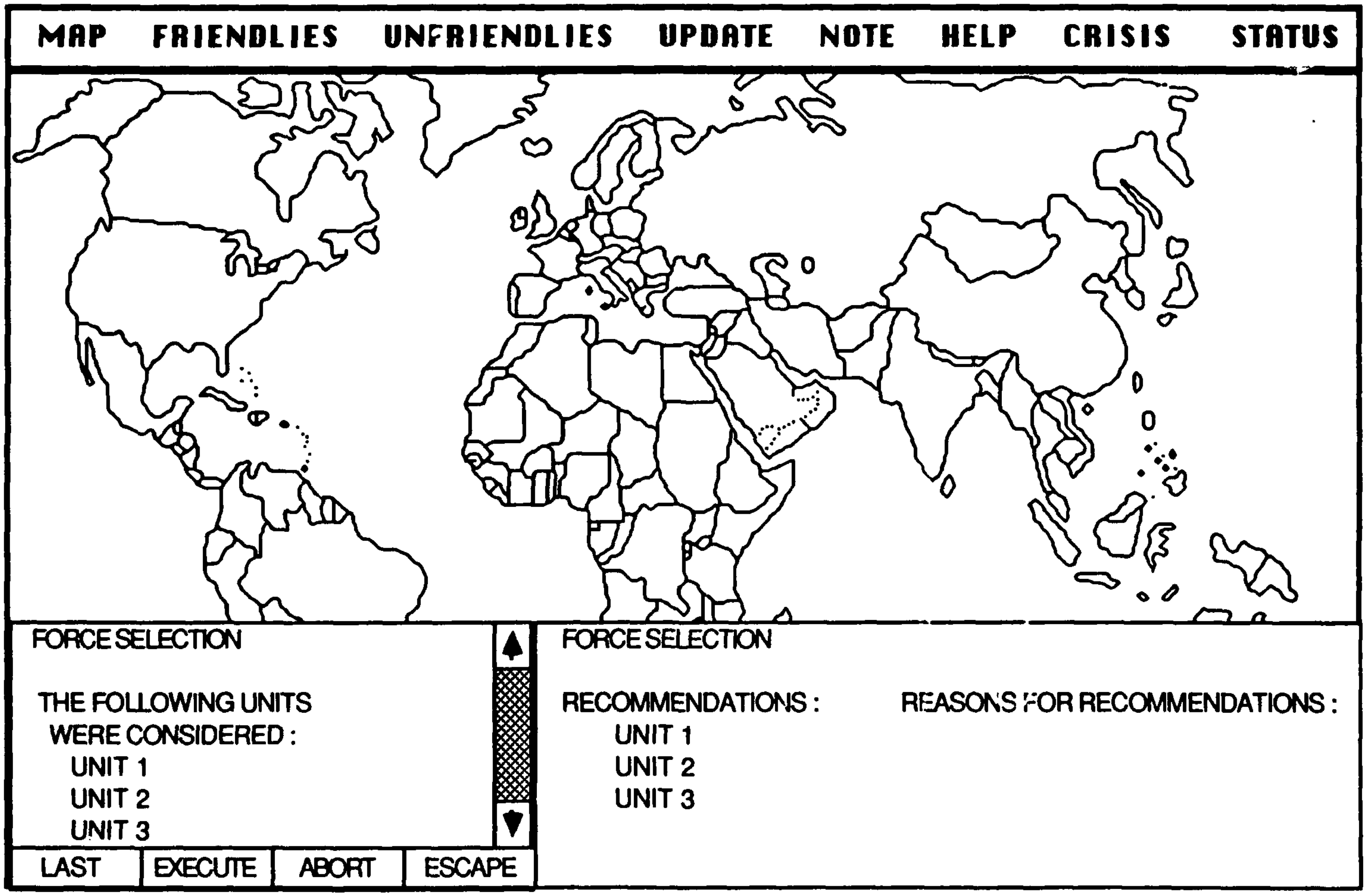


Figure 7 **STORYBOARD 3**

STORYBOARD III

FORCE SELECTION DISPLAY2 (ROUTINE)

PURPOSE: SAME AS DISPLAY1 (PREVIOUS STORY BOARD)

OPTIONS: NONE

NOTES: 1. DISPLAY AT LOWER LEFT GIVES THE USER A CHANCE TO CONFIRM HIS SELECTION OF FORCES TO CONSIDER.

LAST: RETURNS USER TO PREVIOUS DISPLAY.
ALLOWS USER TO CHANGE UNITS TO BE CONSIDERED.

EXECUTE: INITIATES THE DECISION MODEL IN THE BACKGROUND.

ABORT: RETURNS USER TO BEGINNING OF FORCE SELECTION MODULE.

ESCAPE: RETURNS USER TO BASE DISPLAY. (NOT SHOWN)

2. DECISION MODEL EXECUTES AND POSTS RESULTS TO LOWER RIGHT HAND WINDOW IN DISPLAY. THE MODEL SHOULD CONSIDER:

A. UNIT CAPABILITIES: DOCTRINAL AND TRAINED

B. UNIT LOCATION:
TIME TO TARGET, INCLUDING PLANNING AND TRANSPORTATION TIMES.

C. UNIT READINESS:
*PERSONNEL STATUS
*TRAINING STATUS (SPECIAL SKILLS, RECENCY OF TRAINING, ETC.)
*EQUIPMENT STATUS

D. COMMAND AND CONTROL

APPENDIX C

USER'S MANUAL

AND

MAINTENANCE MANUAL

FOR

PLANNER VER. 0

This manual provides the basic instruction needed to operate and maintain the kernel decision aid known as PLANNER. This decision support system was developed using a Z-248 micro-computer with a twenty megabyte hard disk, an 80287 math coprocesser, and 640 kilobytes of memory.

PLANNER is composed of three elements: the spreadsheet, using VP Planner Plus; the data base using VP Info; and the expert system using VP Expert. While the interfaces between these components are not particularly complicated, it is suggested that all users first become familiar with the operation of the individual components before PLANNER is used.

Introduction

This manual is divided into two main sections: the user's guide and the maintenance guide. The first section describes how to activate PLANNER and use it to select a unit for a mission. The limitations of Ver. 0 are explained in this section. The second section provides a listing of the macro codes from the spreadsheet, a listing of the data base relations, and the expert system's code. Brief explanations about each of these elements are included. All code is documented in this section.

General Information

Input Commands. Commands the user should input are identified by capital letters in bold print (e.g., **ENTER** for the Enter/Return key).

Simultaneous Commands. Some commands the user will have to execute by simultaneously depressing two keys. This is true in the execution of all macro commands in the spreadsheet. When this is required, simultaneous commands are identified by the notation **KEY/KEY** (e.g., **ALT/Z**, means depress the ALT and Z keys simultaneously).

Menu Options. PLANNER has menus built into the spreadsheet and the expert system. In the spreadsheet, menu selections are accomplished by using the direction (arrow) keys to move the cursor to the desired entry and pressing **ENTER** to execute your choice. In the expert system, choices are highlighted by using the direction (arrow) keys as in the spreadsheet. The selection, in the expert system,

is made by pressing **ENTER** then **END** once your selection has been made.

Directory Set Up. PLANNER has VP Planner Plus's, VP Info's, and VP Expert's executable files stored in the directory PLANNER on a hard disk. All files necessary to run the system are loaded into this directory by copying the contents of the above program disks into the directory PLANNER. All working files are also located in this directory.

SECTION I: USER'S GUIDE.

PLANNER is a developmental tool. Its main purpose is to demonstrate the efficacy of using existing software and hardware to develop decision aids for operational planners and hence has its limitations. The following text describes how to use PLANNER in its current form as well as its limitations.

Getting Started

Ensure the VP Expert program disk is in the A drive and your PLANNER directory has the program files from each of its component systems. This User's Manual assumes a hard disk configuration.

USING THE MODEL BASE

Turn on the computer, ensuring the printer is on. Change directories to PLANNER. At the prompt type: **VPP**. This allows you to enter the spreadsheet which is the window into the PLANNER system.

You will see a copyright statement presented, strike the **ENTER** key and type: **/fr proto.wks**, and press **ENTER**. This retrieves the PLANNER spreadsheet and enters you into the system. At this time you will see the display in Figure 8. Press **ALT/Z** to begin your consultation.

```
        A         B          C          D          E          F
3
4                         WELCOME TO PLANNER
5
6        PLANNER IS A KERNEL DECISION SUPPORT SYSTEM.  ITS PURPOSE IS
7    TWOFOLD:  FIRST, TO CONSTRUCT A PROTOTYPE DECISION AID THAT WILL ASSIST
8    PLANNERS IN THE SELECTION OF THE MOST CAPABLE AND READILY AVAILABLE UNIT
9    FOR A GIVEN CONTINGENCY MISSION.  SECOND, TO DEMONSTRATE THE EFFICACY
10   OF USING EXISTING COMMERCIAL OFF-THE-SHELF SOFTWARE AND HARDWARE TO
11   DEVELOP THE KERNEL.
12       PLANNER CONSISTS OF THREE PARTS: THE WORKSHEET, THE DATA BASE, AND
13   THE EXPERT SYSTEM.  THE WORKSHEET IS USED TO PERFORM ALL NUMERICAL
14   CALCULATIONS AND UPDATE THE DATABASES AS NECESSARY.  THE DATA BASE STORES
15   INFORMATION ON THE SOF UNIT'S CAPABILITIES AND AVAILABILITIES.  THE EXPERT
16   SYSTEM IS USED TO ELICIT THE MISSION PARAMETERS FROM THE USER AND MATCH A
17   CAPABLE AND AVAILABLE UNIT TO THE MISSION.
18
19
20            ------->Press Alt-Z to use PLANNER<------
21
22
 A3    '

1help 2edit 3name 4abs 5goto 6window 7data 8table 9recalculate 0graph
298K                              20:50                     CAPS          READY
```

Figure 8 Opening Screen

PLANNER presents the display depicted in Figure 9. Follow the instructions on the screen and enter the target's country, latitude, and longitude. PLANNER waits for your entry at the cursor and proceeds only after you've typed your entry and hit **ENTER** for each item.

On the screen you will see PLANNER completing its time to target calculations and updating the data base. When it's completed it will return to the display shown in Figure 10.

```
            B          C          D          E          F          G
25  This portion of planner allows you to update
26  certain data base entries via the spreadsheet
27
28
29
30   1. Enter the target location:
31                           Country:
32                          Latitude:
33                         Longitude:
34
35  Note: Enter LAT-LON in decimal form.
36  East latitudes and south longitudes
37  are entered as negatives.
38  Countries have three or four letter
39  abbreviations see annex C (User's Manual).
40
41
42
43
44
 G31
Enter the target country and press ENTER

297K                                 20:51                  CAPS       INPUT
```

Figure 9 Input Screen

```
          A         B          C          D          E          F
34
35            Note: Enter LAT-LON in decimal form.
36            East latitudes and south longitudes
37            are entered as negatives.
38            Countries have three or four letter
39            abbreviations see annex C (User's Manual).
40
41
42             2. PLANNER has updated the time to target
43             information in the data base.
44
45             3. You now have the option of exiting to
46             to the expert system for help in selecting
47             a unit, browsing the updated data base from
48             the worksheet, or quitting PLANNER.
49
50                 A. Press ALT-E to access the expert system.
51                 B. Press ALT-B to browse the data base.
52                 C. Press ALT-Q to quit PLANNER.
53
 B52    '     C. Press ALT-Q to quit PLANNER.

1help 2edit 3name 4abs 5goto 6window 7data 8table 9recalculate 0graph
294K                                 20:53                  CAPS       READY
```

Figure 10 PLANNER Options

At this point you have the choice of using the expert system. browsing the updated data base, or quitting the system.

ALT/E. Press **ALT/E** to exit to the expert system. A series of instructions will be presented on the screen for you. These instructions will be presented on the screen for fifteen seconds and then printed. After the printing is completed, you are exited to the DOS. Follow the instructions to access and use the expert system. Use of the expert system will be discussed later.

ALT/B. Press **ALT/B**, a data display will be generated for you. This display was created to demonstrate how users can customize their displays based on their needs and desires. Because of the size of the display it is not represented in a figure.

ALT/Q. Press **ALT/Q** and instructions for exiting PLANNER are presented as illustrated in Figure 11. A menu is presented at the bottom of the screen. The menu has three options: PRINT, RESTART, and QUIT. The PRINT option prints the data browse display, saves the file and quits PLANNER. The RESTART option clears the work areas and returns the user to the opening screen. The QUIT option clears the work area, saves the worksheet, and quits PLANNER, returning you to the DOS.

Using the Expert System

After you've chosen the ALT/E option in the worksheet, instructions are printed for you as depicted in Figure 12

and you are exited to the system. Follow the instructions to begin your consultation.

```
        A         B          C          D          E          F
160
161           +---------------------------------------+
162           |      INSTRUCTIONS FOR ALT-Q           |
163           |                                       |
164           |  Please choose an option from         |
165           |  the quit menu below.                 |
166           |  Press --> and <-- to highlight options
167           |  Press ENTER to choose the one        |
168           |  you want.                            |
169           |                                       |
170           +---------------------------------------+
171
172
173
174
175
176
177
178
179
 B164
 PRINT RESTART QUIT
Print data browse and quit.
294K                        20:54                     CAPS       INPUT
```

Figure 11 Quit Screen

INSTRUCTIONS

1. Turn on the printer.
2. When you are returned to the system
you will see the C:\PLANNER> prompt.
TYPE: VPX at the prompt and press ENTER.
3. You are now in the expert system press F6
(Filename) to select the knowledge base.
4. TYPE: Select and press ENTER.
5. Press F4 (Consult) to select the consultation option.
6. Press F2 (Go) to execute the consultation.
7. Proceed with the consultation.
8. Upon completion of the consultation, press F7 (Quit)
to return to the main menu.
9. Press F8 (Quit) to exit the expert system.
10. You are now back in the DOS system, the
prompt C:\PLANNER> will be displayed. TYPE: Exit
and press ENTER to access the worksheet.
11. Follow the instructions on the screen.

Figure 12 Expert System Access Instructions

```
          QUESTIONS AS PLANNER ASKS YOU.  THE FIRST QUESTION
          PRESENTS A MENU, USE THE DIRECTION KEYS TO HIGHLIGHT
          YOUR SELECTION THEN PRESS ENTER FOLLOWED BY END TO
          MAKE YOUR CHOICE.
WHAT IS THE MISSION?
RAID                        INTERDICT                  CI
STRRECON                     UWOPS                      SEARECON
GRECON

WHAT IS TARGET COUNTRY?
AFG

WHAT IS THE DESIRED TIME TO TARGET, IN HOURS
(DECIMAL FORM)?
72

WHAT IS THE SIZE OF THE TARGET, SQ. KM.?
50

HOW MANY FRIENDLIES ARE IN THE AREA?
20
```

```
Enter to select     ? & Enter for Unknown     /Q to quit

RAID IS BN175RGR'S PRIMARY MISSION.
       BN175RGR IS CAPABLE AND AVAILABLE BUT NOT
       TARGETED AT AFG.

RAID IS BN15SF'S TERTIARY MISSION.
       AFG IS BN15SF'S PRIMARY TARGET COUNTRY.
       BN15SF IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

RAID IS AC01BN5SF'S TERTIARY MISSION.
       AFG IS AC01BN5SF'S PRIMARY TARGET COUNTRY.
       AC01BN5SF IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

RAID IS BN25SF'S TERTIARY MISSION.
       AFG IS BN25SF'S TERTIARY TARGET COUNTRY.
       BN25SF IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

RAID IS BC02BN5SF'S TERTIARY MISSION.
       AFG IS BC02BN5SF'S TERTIARY TARGET COUNTRY.
       BC02BN5SF IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

PLANNER'S EXPERT SYSTEM RECOMMENDS THE UNITS LISTED
           ABOVE FOR THE RAID MISSION IN AFG.  ALL UNITS
           RECOMMENDED ARE AVAILABLE WITHIN THE TIME CONSTRAINTS
           IMPOSED.  IF NO UNITS ARE PRINTED OUT ABOVE THIS MESSAGE
           THEN NONE OF THE UNITS IN THE DATA BASE ARE AVAILABLE OR
           TRAINED FOR THE MISSION UNDER CONSIDERATION.  IN THIS
           CASE, RECOMMEND YOU RE-EVALUATE YOUR MISSION REQUIREMENTS
           AND ENTER NEW PARAMETERS INTO THE EXPERT SYSTEM.
```

Figure 13 Expert System Entry Display and Output

The first question asked by the expert system is: What is the mission? A menu of mission choices is displayed. These are the only missions PLANNER currently recognizes. The following definitions apply to the menu selections:

RAID: Self Explanatory

INTERDICT: Interdiction

CI: Counter Insurgency

STRRECON: Strategic Reconnaissance

UWOPS: Underwater Operations

SEARECON: Seaborne Reconnaissance

GRRECON: Reconnaissance Other Than Strategic

To make a selection use the arrow keys to highlight your choice. Press **ENTER** then **END** to make your selection.

The second question the system asks is: What is the target country?: You must type the target country abbreviation and press **ENTER**. The current version of PLANNER recognizes four country abbreviations:

AFG: Afghanistan

IRAN: Iran

IRAQ: Iraq

PAK: Pakistan

The third question asked is: What is the desired time to target, in hours? Enter the time the unit has to reach the target from the time it receives the order to execute, then press **ENTER**.

The fourth question asked is: What is the size of the target? Enter the amount of physical area a unit needs to control to be successful in the mission and press **ENTER**.

The last question asked is: How many friendlies are in the target area? Enter the number of friendly personnel in the area the executing unit must be able to protect and control, and press **ENTER**.

For a mission of RAID in Afghanistan with a 72 hour time to target restriction, target area of 50 square kilometers, and 20 friendlies, the input screen and subsequent output are depicted in Figure 13.

PLANNER's expert system recommends units that are available, i.e., they can make it to the target area in time, and capable, i.e., they can handle the target size and friendlies, they are trained for the mission, and are possibly targeted at the country in question.

PLANNER categorizes every unit in the data base into one of the thirteen categories listed below:

CAP1C1: Unit's primary mission, primary target country, and unit is available

CAP1C2: Unit's primary mission and secondary target country and unit is available

CAP1C3: Unit's primary mission and tertiary target country and unit is available

CAP1: Unit's primary mission and unit is available

CAP2C1: Unit's secondary mission and primary target country and unit is available

CAP2C2: Unit's secondary mission, secondary target country and unit is available

CAP2C3: Unit's secondary mission, tertiary target country and unit is available

CAP2: Unit's secondary mission and unit is available

CAP3C1: Unit's tertiary mission, primary target country and unit is available

CAP3C2: Unit's tertiary mission, secondary target country and unit is available

CAP3C3: Unit's tertiary mission, tertiary target country and unit is available

CAP3: Unit's tertiary mission

NONCAP/AVAIL: Not capable and/or not available

PLANNER's expert system asks the series of questions above to determine the values of its decision variables. It compares the decision variable with certain data fields that define each unit in the data base. It strips the data base, Special.DBF, one record, i.e. unit, at a time and classifies every unit into one of the mission capable/available categories or the non-mission capable and/or available category. All units classified as capable and available are displayed as depicted in Figure 13.

After the output is printed you can perform another consultation by pressing **F2** and changing your mission parameters. This allows a very rough form of sensitivity analysis.

When you've finished your consultation with the expert system, follow the printed instructions to return to the spreadsheet. Once you've returned you have the choice of browsing the data base via **ALT/B** or exiting the system via **ALT/Q**.

Comments on the Worksheet

1. The calculation and constant work area is located in the cell range AR85 to BN93. All calculations are performed here and transferred to the display area. The user should become familiar with this area.

2. The Great Circle Distance Equation used to calculate the distance from the unit's current location to the target is:

$$D = 60 \times COS^{-1}[(\sin L1)(\sin L2)+(\cos L1 \times \cos L2 \times \cos DLo)] \times 180/PI$$

Where,

L1 = Latitude of the Unit Location

L2 = Latitude of the Target

DLo = Difference between Unit Location and Target Longitudes

Note: If target and unit longitudes are exactly equal, the equation will "blow up".

PLANNER converts all degree entries to radians before calculations are made.

3. Current worksheet time to target calculations ignore the need to stop, hence air refueling is assumed if target distance is greater than the range of the aircraft.

4. The distance to target calculation ignores over-flight rights. It calculates the most direct Great Circle route to the target for each unit's current location.

Comments on the Expert System

1. The mission definitions were derived from the Joint Special Operations Planning Workshop documents prepared by the USAF Special Operations School at Hurlburt Field, Florida in February 1986. The problem with using these types of definitions is the lack of consensus on mission definitions and who should perform these missions, as well as the priority of each mission assigned to a unit. Research indicates a great deal of inter-service parochialism which results in the, "my force can do it best" attitude each service seems to exhibit. USSOCOM is trying to deconflict these attitudes and establish priorities by publishing joint doctrine and operating procedures. Until these changes are fielded and accepted, decision aiding technology of the type fielded here will be of marginal use to mission planners.

2. The data base structures originally constructed had to be modified in order for the expert system to function. SPECIAL.DBF was created to function with the expert system. Consequently, MISSION.DBF and COUNTRY.DBF are not used in the system.

3. The decision model embedded in the expert system is very narrow in scope. It includes only five variables in its algorithm. In reality, the decision process consists of

many more variables. The model needs to be expanded to include such considerations as the threat, special equipment and skills needed on the mission, supportability, and command and control. The current version of PLANNER should be progressively improved and iterated to establish a more extensive and realistic expert system.

SECTION II: MAINTENANCE GUIDE

PLANNER has three components that require maintenance and documentation. This guide the documentation and code for Version 0 of PLANNER. It is divided into three parts: 1) Part A is a listing of the macro codes used in spreadsheet program V P Planner Plus; 2) Part B is a listing of the data base relations created with the relational data base system V P Info; 3) Part C is a listing of the expert system code developed using the expert system development tool
V P Expert.

Parts A through C are presented as independent enclosures for ease of reading.

PART A: SPREADSHEET MACROS

TOOL: V P PLANNER PLUS

COST: $82.00

Macros are a way of programming a spreadsheet to perform a set of repetitive functions. Macros are simply the recording of keystrokes on the spreadsheet for later recall and use. By pre-recording a set of keystrokes, normally input as the user conducts his business, a spreadsheet can be made to execute complex and time consuming mathematical models without having to input the keystrokes with every iteration of the model. The listings in Part A are the macros embedded in the spreadsheet PROTO.WKS which serves as PLANNER's model base. The reader should become familiar with the macro input symbols of V P Planner Plus before attempting to modify this code.

NAME: ALT/Z

PURPOSE: START PLANNER

LOCATION: AA10

```
{f5}a25~{r}
This portion of planner allows you to update~{d}
certain data base entries via the spreadsheet~{d}
{f5}b30~
 1. Enter the target location:~{d}
                      Country:~{d}
                     Latitude:~{d}
                    Longitude:~
{f5}b35~
Note: Enter LAT-LON in decimal form.~{d}
East latitudes and south longitudes~{d}
are entered as negatives.~{d}
Countries have three or four letter~{d}
abbreviations see annex C (User's Manual).~
{f5}A31~{r 6}
/xlEnter the target country and press ENTER~g31~{d}
/xnEnter the target Latitude and press ENTER~g32~{d}
/xnEnter the target Longitude and press ENTER~g33~
{f5}aa100~
/deddtsof.dbf~~~rq
{f5}aa110~
/deddtspecial.dbf~~~rq
{distance}
/rvae101.aj107~ae111.aj117~
/deda~q
{F5}A34~{D 8}{R}
 2. PLANNER has updated the time to target~{d}
 information in the data base.~{d 2}
 3. You now have the option of exiting to~{d}
 to the expert system for help in selecting~{d}
 a unit, browsing the updated data base from~{d}
 the worksheet, or quitting PLANNER.~{d 2}
     A. Press ALT-E to access the expert system.~{d}
     B. Press ALT-B to browse the data base.{d}~
     C. Press ALT-Q to quit PLANNER.~
```

NAME: DISTANCE

PURPOSE: CALCULATES DISTANCE TO TARGET AND
UPDATES DATA BASE
LOCATION: AK10

```
{f5}g32~/c~as86~
{f5}g33~/c~as87~
{f5}ac101~
{for count,1,7,1,far}
{f5}aa100~

/c~as88~
{r}/c~as89~
{r}/rvat90~~
/rv~aw86~
{r}/rv~ax87~
{r}/rv~ax88~
{r}/rv~ax89~
{r}/rvax86~~
{r}/rvax90~~
{l 7}{d}
```

NAME: ALT/E

PURPOSE: EXIT USER TO EXPERT SYSTEM

LOCATION: AQ 8

```
{f5}a130~{r}~
You are now ready to exit the worksheet~{d}
for the expert system. Follow the instructions~{d}
below, which will be printed for you.~{d 4}
            INSTRUCTIONS{d 2}
 1. Turn on the printer.~{d}
 2. When you are returned to the system~{d}
 you will see the C:\PLANNER> prompt.~{d}
 TYPE: VPX at the prompt and press ENTER.~{d}
 3. You are now in the expert system press F6~{d}
 (Filename) to select the knowledge base.~{d}
 4. TYPE: Select and press ENTER.~{d}
 5. Press F4 (Consult) to select the consultation option.~{d}
 6. Press F2 (Go) to execute the consultation.~{d}
 7. Proceed with the consultation.~{d}
 8. Upon completion of the consultation, press F7 (Quit)~{d}
 to return to the main menu.~{d}
 9. Press F8 (Quit) to exit the expert system.~{d}
 10. You are now back in the DOS system, the~{d}
 prompt C:\PLANNER> will be displayed.  TYPE: Exit~{d}
 and press ENTER to access the worksheet.~{d}
 11. Follow the instructions on the screen.~{d}
/xwl5~
{beep}
/ppral35.il55~gq
{exsys}
/rebl30.il55~
{f5}a45~
```

NAME: ALT/S

PURPOSE: EXIT USER TO DOS

LOCATION: AZ 10

```
/s
```

NAME: ALT/B

PURPOSE: CREATE DATA BROWSE DISPLAY

LOCATION: BE 10

```
{f5}a60~{r}~
                DATA BROWSE ~{d 2}
The following display represents some examples of how~{d}
the data base information can be displayed~{d}
to the user through the spreadsheet's ~{d}
macro programming facilities. Reports and~{d}
displays can be rapidly customized to suit the users' needs.~{d 2}
 1. The Transportation Summary was designed to~{d}
 give planners a look at how the type of aircraft~{d}
 can affect a unit's time to target.~{d 2}
 2. The SOF, MISSION, & COUNTRY displays are the actual~{d}
 data base relations pulled directly out of the data base~{d}
 for inspection in the worksheet.~{d 3}
/rvab101.ab107~bg87.bg93~
/rvae101.ae107~bi87.bi93~
TRANSPORTATION SUMMARY~{d 1}
/rvbg85.bo93~~{r 9}{d}
/rvak100.ak107~~
/rfgd80.d86~
{f5}a88~{r}
NOTE: For each stop required, add the time for each~{d}
      stop to the unit's calculated time to target in the ~{d}
      table above. Use the table below to determine the ~{d}
      average length of a given stop for a given aircraft.~{F5}b93~
/rvca85.ce88~~
{d 7}{l}
/deddtsof.dbf~~~rq
{d 10}
/deddtmission.dbf~~~rq
{d 10}
/deddtcountry.dbf~~~rq
/rcsb78.o78~12~
{f5}a60~
```

NAME: ALT/Q

PURPOSE: PROVIDES QUIT MENU INSTRUCTIONS
AND CALLS QUIT MENU
LOCATION: BP 10

```
{f5}a160~{r}{d 2}
        INSTRUCTIONS FOR ALT-Q~{d 2}
    Please choose an option from~{d}
     the quit menu below.~{d}
     Press --> and <-- to highlight options~{d}
     Press ENTER to choose the one~{d}
     you want.~
/tdbb161.e169~q
/xmqmenu~
```

NAME: QMENU

PURPOSE: PROVIDE THE QUIT MENU OPTIONS

LOCATION: BV 10

```
PRINT                    RESTART                 QUIT
Print data browse anStart PLANNER again.Quit PLANNER without printing
{f5}b77~                 /rea25.o170~            {f5}a25~/rea25..o170~
/rvab101.ab107~bg87.{f5}a3~                      {f5}a3~
/rvae101.ae107~bi87.bi93~                        /fsproto~{f3}
TRANSPORTATION SUMMARY~{d 1}                     /qy
/rvbg85.bo93~~{r 9}{d}
/rvak100.ak107~~
/rfgd80.d86~
{f5}a88~{r}
NOTE: For each stop required, add the time for each~{d}
      stop to the unit's calculated time to target in the ~{d}
      table above. Use the table below to determine the ~{d}
      average length of a given stop for a given aircraft.~{F5}b93~
/rvca85.ce88~~
{d 7}{l}
/deddtsof.dbf~~~rq
{d 10}
/deddtmission.dbf~~~rq
{d 10}
/deddtcountry.dbf~~~rq
/rcsb78.o78~12~
/ppoowyqq
/pprb77.k86~gq
/pprb88.f96~gq
/ppra100.o107~gq
/ppra110.g117~gq
/ppra120.g127~gq
/ppoownqq
/rea25.o170~
{f5}a3~
/fsproto~{f3}
/qy
```

NOTE THIS MACRO IS COMPOSED OF THREE COMPONENTS:
THE PRINT OPTION; THE RESTART OPTION; AND
THE QUIT OPTION. EACH IS SHOWN
IN THE FOLLOWING PAGES.

```
NAME: PRINT OPTION
      OF MENU
PURPOSE: PRINT DATA DISPLAY
         AND QUIT
LOCATION: BV 10

PRINT
Print data browse and quit.
{f5}b77~
/rvab101.ab107~bg87.bg93~
/rvae101.ae107~bi87.bi93~
TRANSPORTATION SUMMARY~{d 1}
/rvbg85.bo93~~{r 9}{d}
/rvak100.ak107~~
/rfgd80.d86~
{f5}a88~{r}
NOTE: For each stop required, add the time for each~{d}
      stop to the unit's calculated time to target in the ~{d}
      table above. Use the table below to determine the ~{d}
      average length of a given stop for a given aircraft.~{F5}b93~
/rvca85.ce88~~
{d 7}{l}
/deddtsof.dbf~~~rq
{d 10}
/deddtmission.dbf~~~rq
{d 10}
/deddtcountry.dbf~~~rq
/rcsb78.o78~12~
/ppoowyqq
/pprb77.k86~gq
/pprb88.f96~gq
/ppra100.o107~gq
/ppra110.g117~gq
/ppra120.g127~gq
/ppoownqq
/rea25.o170~
{f5}a3~
/fsproto~{f3}
/qy
```

NAME: RESTART OPTION
      OF QMENU
PURPOSE: RESTART
  WORK SESSION
LOCATION: BW 10

```
RESTART
Start PLANNER again.
/rea25.o170~
{f5}a3~
```

NAME: QUIT OPTION
      OF QMENU
PURPOSE: QUIT PLANNER

LOCATION: BX 10

```
QUIT
Quit PLANNER without printing.
{f5}a25~/rea25..o170~
{f5}a3~
/fsproto~{f3}
/qy
```

PART B: DATA BASE RELATIONS

TOOL: V P INFO

COST: $42.00

PLANNER's data base consists of four relations: SOF, SPECIAL, COUNTRY, and MISSION. SOF, COUNTRY, and MISSION were originally designed to support both the spreadsheet and the expert system. During the development of PLANNER it was determined that a new relation, SPECIAL, was needed to ensure the proper execution of the expert system. Consequently, the relations COUNTRY and MISSION are used by neither the spreadsheet nor the expert system. They simply provide a quick reference for the country targeting and mission assignment priorities of each unit.

The relations established in PLANNER are neither pretty nor sophisticated. They are a result of the researcher's 'brute force' method of data structuring. However, they do work and within the limits of this kernel system work well. Much work needs to be done in the area of data structuring in PLANNER. The relations need to be cleaned up and a true relational data base established and maintained for PLANNER.

Table 1 SOF.DBF

Field Name	Description	Purpose
NAME	Unit description	Unique ID for unit
LAT	Unit Latitude	Used in distance calculations
LON	Unit Longitude	Used in distance calculations
DISTTGT	Distance to Target	Used in time to target calculations
TAVAIL	Time unit available	Used in time to target calculations
PTIME	Planning time	Used in time to target calculations
RTIME	Rehearsal time	Used in time to target calculations
TRTIME	Transit time to target	Used in time to target calculations
TTGT	Time to target	Used by expert system
UNSIZE	Unit size	Information
SUNIT	Number of sub-units present	Information
TGTAC	Target area capable	Used by expert system
TGTPC	Target people capable	Used by expert system
GARRISON	Home station	Information

Table 2 MISSION.DBF

Field Name	Description	Purpose
NAME	Unit description	Unique ID for unit
MSN1	Priority mission one	Used in expert system
MSN2	Priority mission two	Used in expert system
MSN3	Priority mission three	Used in expert system
MSN4	Priority mission four	Not used
MSN5	Priority mission five	Not used

Table 3 COUNTRY.DBF

Field Name	Description	Purpose
Name	Unit description	Unique ID for unit
CTRY1	Target country one	Used in expert system
CTRY2	Target country two	Used in expert system
CTRY3	Target country three	Used in expert system
CTRY4	Target country four	Not used
CTRY5	Target country five	Not used

Table 4 SPECIAL.DBF

Field Name	Description	Purpose
Name	Unit description	Unique ID for unit
LAT	Unit Latitude	Used in distance calculations
LON	Unit Longitude	Used in distance calculations
DISTTGT	Distance to Target	Used in time to target calculations
TAVAIL	Time unit available	Used in time to target calculations
PTIME	Planning time	Used in time to target calculations
RTIME	Rehearsal time	Used in time to target calculations
TRTIME	Transit time to target	Used in time to target calculations
TTGT	Time to target	Used by expert system
UNSIZE	Unit size	Information
SUNIT	Number of sub-units present	Information
TGTAC	Target area capable	Used by expert system
TGTPC	Target people capable	Used by expert system
GARRISON	Home station	Information
MSN1	Priority one mission	Used by expert system
MSN2	Priority two mission	Used by expert system
MSN3	Priority three mission	Used by expert system
CTRY1	Target country one	Used by expert system
CTRY2	Target country two	Used by expert system
CTRY3	Target country three	Used by expert system

PART C: EXPERT SYSTEM CODE

TOOL: V P EXPERT

COST: $42.00

PLANNER's expert system code is enclosed in the following pages. The development of the expert system proved to be somewhat difficult for the researcher. The main reason for this difficulty was the researchers lack of experience with expert systems prior to this thesis. The name of the file is SELECT.KBS and the code is documented internally.

```
RUNTIME;

!RUNTIME PROVIDES ONE WINDOW DURING THE CONSULTATION

ACTIONS

!THE ACTIONS BLOCK CAN BE THOUGHT OF AS THE MAIN PROGRAM
!ALL VARIABLES THE PROGRAM SEEKS A VALUE FOR ARE LISTED HERE

  DISPLAY 'WELCOME TO PLANNER'S EXPERT SYSTEM.  ANSWER THE
          QUESTIONS AS PLANNER ASKS YOU.  THE FIRST QUESTION
          PRESENTS A MENU, USE THE DIRECTION KEYS TO HIGHLIGHT
          YOUR SELECTION THEN PRESS ENTER FOLLOWED BY END TO
          MAKE YOUR CHOICE.'

!DISPLAY TELLS THE PROGRAM TO DISPLAY A MESSAGE ON
!THE SCREEN

        FIND MSN
        FIND PLACE
        FIND MAXTTGT
        FIND SIZETGT
        FIND NUMFRND

!THE FIND COMMANDS ARE INSTRUCTING THE PROGRAM TO FIND
!VALUES FOR THE VARIABLES LISTED, THESE VARIABLES WILL
!HAVE THEIR VALUES INPUT BY THE USER THROUGH THE INPUT SCREEN.

      WHILEKNOWN NAME
        GET ALL,C:SPECIAL,ALL
          FIND CAP1C1
          RESET CAP1C1
          FIND CAP1C2
          RESET CAP1C2
          FIND CAP1C3
          RESET CAP1C3
          FIND CAP1
          RESET CAP1
          FIND CAP2C1
          RESET CAP2C1
          FIND CAP2C2
          RESET CAP2C2
          FIND CAP2C3
          RESET CAP2C3
```

```
        FIND CAP2
        RESET CAP2
        FIND CAP3C1
        RESET CAP3C1
        FIND CAP3C2
        RESET CAP3C2
        FIND CAP3C3
        RESET CAP3C3
        FIND CAP3
        RESET CAP3
    END

!THE WHILEKNOWN COMMAND INSTRUCTS THE PROGRAM TO LOOP
!THROUGH THE DATA BASE.  IT TAKES EACH RECORD FROM THE DATA
!RELATION SOF.DBF AND ATTEMPTS TO CLASSIFY IT INTO ONE OF
!CATEGORIES ABOVE (i. e. CAP1CI, CAP1C2,....CAP3).  THE FIND
!COMMAND INITIATES ONE LOOP FOR EACH UNIT CLASSIFICATION
!CATEGORY.  THE RESET COMMAND ALLOWS THE WHILEKNOWN LOOP
!CONTINUE AFTER ALL VALUES ARE FOUND FOR EACH UNIT CLASSIFICATION
!VARIABLE

  PRINTON

!TURNS THE PRINTER ON FOR THE DISPLAY MESSAGE

  DISPLAY "PLANNER'S EXPERT SYSTEM RECOMMENDS THE UNITS LISTED
           ABOVE FOR THE {MSN} MISSION IN {PLACE}.  ALL UNITS
           RECOMMENDED ARE AVAILABLE WITHIN THE TIME CONSTRAINTS
           IMPOSED.  IF NO UNITS ARE PRINTED OUT ABOVE THIS MESSAGE
           THEN NONE OF THE UNITS IN THE DATA BASE ARE AVAILABLE OR
           TRAINED FOR THE MISSION UNDER CONSIDERATION.  IN THIS
           CASE, RECOMMEND YOU RE-EVALUATE YOUR MISSION REQUIREMENTS
           AND ENTER NEW PARAMETERS INTO THE EXPERT SYSTEM.

!THIS MESSAGE IS PRINTED AFTER THE EXPERT SYSTEM COMPLETES ITS
!SEARCH FOR ALL THE VARIABLES LISTED ABOVE

  PRINTOFF

!TURNS THE PRINTER OFF

EJECT;
```

```
!EJECTS THE PAGE IN THE PRINTER


RULE 1
 IF MSN=(MSN1) AND
    PLACE=(CTRY1) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP1C1=(NAME)
       RED1=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP1C1}'S PRIMARY MISSION.
       {PLACE} IS {CAP1C1}'S  PRIMARY TARGET COUNTRY.
       {CAP1C1} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


RULE 2
 IF MSN=(MSN1) AND
    PLACE=(CTRY2) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP1C2=(NAME)
       RED2=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP1C2}'S PRIMARY MISSION.
       {PLACE} IS {CAP1C2}'S SECONDARY TARGET COUNTRY.
       {CAP1C2} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;

RULE 3
 IF MSN=(MSN1) AND
    PLACE=(CTRY3) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP1C3=(NAME)
       RED3=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP1C3}'S PRIMARY MISSION.
       {PLACE} IS {CAP1C3}'S TERTIARY TARGET COUNTRY.
       {CAP1C3} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


 RULE 4
```

```
  IF MSN=(MSN1) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC) AND
    RED1<>(NAME)  AND
    RED2<>(NAME)  AND
    RED3<>(NAME)
  THEN CAP1=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP1}'S PRIMARY MISSION.
       {CAP1} IS CAPABLE AND AVAILABLE BUT NOT
       TARGETED AT {PLACE}.

  PRINTOFF;


RULE 5
 IF MSN=(MSN2) AND
    PLACE=(CTRY1) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP2C1=(NAME)
       WHITE1=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP2C1}'S SECONDARY MISSION.
       {PLACE} IS {CAP2C1}'S  PRIMARY TARGET COUNTRY.
       {CAP2C1} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


RULE 6
 IF MSN=(MSN2) AND
    PLACE=(CTRY2) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP2C2=(NAME)
       WHITE2=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP2C2}'S SECONDARY MISSION.
       {PLACE} IS {CAP2C2}'S SECONDARY TARGET COUNTRY.
       {CAP2C2} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


RULE 7
 IF MSN=(MSN2) AND
    PLACE=(CTRY3) AND
    MAXTTGT>=(TTGT) AND
```

```
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP2C3=(NAME)
       WHITE3=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP2C3}'S SECONDARY MISSION.
       {PLACE} IS {CAP2C3}'S TERTIARY TARGET COUNTRY.
       {CAP2C3} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


RULE 8
  IF MSN=(MSN2) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC) AND
    WHITE1<>(NAME) AND
    WHITE2<>(NAME) AND
    WHITE3<>(NAME)
  THEN CAP2=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP2}'S SECONDARY MISSION.
       {CAP2} IS CAPABLE AND AVAILABLE BUT NOT
       TARGETED AT {PLACE}.

  PRINTOFF;


RULE 9
 IF MSN=(MSN3) AND
    PLACE=(CTRY1) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP3C1=(NAME)
        BLUE1=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP3C1}'S TERTIARY MISSION.
       {PLACE} IS {CAP3C1}'S PRIMARY TARGET COUNTRY.
       {CAP3C1} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


RULE 10
 IF MSN=(MSN3) AND
    PLACE=(CTRY2) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP3C2=(NAME)
```

```
        BLUE2=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP3C2}'S TERTIARY MISSION.
       {PLACE} IS {CAP3C2}'S SECONDARY TARGET COUNTRY.
       {CAP3C2} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


RULE 11
 IF MSN=(MSN3) AND
    PLACE=(CTRY3) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC)
  THEN CAP3C3=(NAME)
        BLUE3=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP3C3}'S TERTIARY MISSION.
       {PLACE} IS {CAP3C3}'S TERTIARY TARGET COUNTRY.
       {CAP3C3} IS TRAINED, AVAILABLE, AND TARGETED FOR THE MISSION.

  PRINTOFF;


RULE 12
  IF MSN=(MSN3) AND
    MAXTTGT>=(TTGT) AND
    SIZETGT<=(TGTAC) AND
    NUMFRND<=(TGTPC) AND
    BLUE1<>(NAME) AND
    BLUE2<>(NAME) AND
    BLUE3<>(NAME)
  THEN CAP3=(NAME)
  PRINTON
  DISPLAY  '{MSN} IS {CAP3}'S TERTIARY MISSION.
       {CAP3} IS CAPABLE AND AVAILABLE BUT NOT
       TARGETED AT {PLACE}.

  PRINTOFF;

!EACH RULE SEEKS UNIT TO MATCH A SINGLE CATEGORY OF
!MISSION AVAIALBILITY/CAPABILITY.  IF A RULE IS 'FIRED'
!THE DISPLAY MESSAGE IS PUT TO THE SCREEN AND SENT TO THE
!PRINTER.  THE RED, WHITE, AND BLUE VARIABLES ARE USED TO
!A UNIT FROM BEING DOUBLE CLASSIFIED, e.g. BEING CLASSIFIED
!AS A CAP1C1 AND A CAP1 UNIT.

ASK MSN : 'WHAT IS THE MISSION?';


CHOICES MSN : RAID,INTERDICT,CI,STRRECON,UWOPS,SEARECON,GRECON;
```

```
ASK PLACE : "WHAT IS TARGET COUNTRY?";

ASK MAXTTGT : "WHAT IS THE DESIRED TIME TO TARGET, IN HOURS
(DECIMAL FORM)?";

ASK SIZETGT : "WHAT IS THE SIZE OF THE TARGET, SQ. KM.?";

ASK NUMFRND : "HOW MANY FRIENDLIES ARE IN THE AREA?";


!THE QUESTIONS ABOVE ARE DIPLAYED ON THE SCREEN.  THE
!SYSTEM WAITS UNTIL THE USER INPUTS A VALUE BEFORE CONTINUING
!THE CHOICES STATEMENT PUTS A MENU ON THE SCREEN FOR THE USER
!SELECT FROM.


!PLURAL VARIABLES ARE THOSE THAT CAN HAVE MORE THAN ONE VALUE
!FOR EXAMPLE, THERE MAY BE MORE THAN ONE CAP1C1 UNIT IN THE DATA
!BASE.  THIS FEATURE ALLOWS THE EXPERT SYSTEM TO CLASSIFY ALL
!UNITS INTO ONE OF THE ABOVE MISSION CAPABLE CATEGORIES WITHOUT
!OVER-WRITING ANY UNITS CLASSIFIED EARLY IN THE SEARCH.


PLURAL: CAP1C1,CAP1C2,CAP1C3,CAP1;
PLURAL: CAP2C1,CAP2C2,CAP2C3,CAP2;
PLURAL: CAP3C1,CAP3C2,CAP3C3,CAP3;
PLURAL: RED1,RED2,RED3;
PLURAL: WHITE1,WHITE2,WHITE3;
PLURAL: BLUE1,BLUE2,BLUE3;
```

APPENDIX D

EVALUATION

Sprague and Carlson's [2] proposed evaluation framework for DSS focuses on four measures: Productivity measures, Process measures, Perception measures, and Product measures.

Productivity measures are concerned with a DSS's impact on the decision, in terms of the time it takes to reach a decision, the cost of the decision, and the results of the decision.

Process measures are concerned with the decision making process itself. The number of alternatives a DSS generates, the time lines of a decision, and the number of analyses completed are examples of process measures.

Perception measures focus on the decision maker. The way a decision maker understands, uses, and learns about the DSS are of concern in this measure.

Product measures are concerned with the technical aspects of a DSS. Items such as response time, data capacity, reliability, and cost fall in this category.

The following pages advance some ideas of what to measure in a DSS that supports the military operational planner.

APPLICATION

The specific DSS we are trying to evaluate deals with the selection of military forces for application in a crisis situation. The process is not well defined, extremely fluid, and time sensitive. The following paragraphs deal with the application of Sprague and Carlson's evaluation framework to the force selection problem.

PRODUCT MEASURES

1. Does the system have real time access to intelligence, transportation, and unit readiness data bases?

2. Is the system available at all times?

3. Is there a back-up for maintenance periods?

4. Can the system support multiple users working on the same problem?

5. How often do we expect the system to fail?

6. How many back-ups are in place? What is the average time to repair?

7. What are the explicit costs in developing, maintaining, operating, and acquiring the system?

8. Is the system compatible with anticipated technological breakthroughs?

9. What are the training requirements for users and supporters?

10. Does it have a wide range of representational capability? (i.e., Can the data be manipulated through displays and printouts to augment the user's comprehension of a problem?)

11. Can the system capture the user's decision process representation by recording all screen displays used?

12. What is the average time between user query and screen display?

PERCEPTION MEASURES (Impact on the Decision Maker)

1. Is the system easy to use?

2. Do the users 'feel good' about using the system in terms of:

   - Information available
   - Courses of Action generated
   - Time horizons and constraints
   - Ability to consult with other experts
   - Ability to portray Courses of Action and implications, graphically, (Sell Ideas)
   - Ability to assess the problem (i.e., retrieve information about the target area, enemy, friendly units, historical analogies, political implications, economic implications, etc.)
   - Matching user's style

3. Does the DSS allow the user to control it? (i.e., Can the user roam about the system to make decisions using his own methods or is he locked into a specific path?)

4. Does the user feel his decision was correct?

5. Does the user feel the DSS is useful or a hindrance?

PROCESS MEASURES (Impact on Decision Making)

1. Can the DSS support many types of Crisis Planning requirements without massive data restructuring?

2. Can multiple analyses of problems be executed within acceptable time limits?

3. Are set up times acceptable, given crisis time horizon?

4. Does the system function within organizational guidelines? (i.e., procedures and structure)

5. How does the DSS affect other people within the organization? (i.e., perceptions that DSS will replace people; DSS causes extra work, etc.)

6. Did decision maker "feel good" after each phase of his decision process? (i.e., Did he feel good about: how he assessed the mission, the courses of action he generated; the course of action he selected; and the plan he published?)

PRODUCTIVITY MEASURES

1. Was the crisis plan formulated and approved within acceptable time limits? Note: The concept of an "acceptable time limit" is not an easy one to define. It will be assumed for now that acceptable is what is specified by the commander at the outset of the crisis.

2. Was the cost of making the decision (implementing the plan) worthwhile in terms of: casualties, time, dollars, political fallout, economic fallout, etc.

3. Were the estimates of casualties, time, etc. generated by the DSS in line with what really happened after the plan was executed? (i.e., How good were your assumptions?)

4. Did the plan work?

ANNEX E

HOOK BOOK

The following text represents the researcher's ideas and thoughts captured during the DSS development. These ideas germinated as the DSS evolved through the adaptive design process. The text entries here appear in the same form as when they were recorded on note cards. Many of the entries appear to be a "flow of consciousness" rendering of an idea while others appear more structured. The reader should note that these entries are the researcher's method of recording the development of the DSS and serve as a method for documenting possible future improvements.

Decision Support Systems in General

-- 29 Mar 87 -- DSSs appear to use 'historical' data as their starting point. They then use this data and models to support a decision maker. System is supposed to be flexible enough to allow a decision maker to attack a problem in a way in which he feels comfortable, emphasis is on avoiding a 'dogmatic' approach to problem solving. It seems logical.

-- 5 Aug 87 -- Designers of systems perceive the 'ideal' user much differently than the 'actual' user. The designer's 'ideal' user tends to be very much like him/her-self. Implication: While designers have designed systems for the 'ideal' user they in effect designed a system for themselves! Do designer's miss the boat?

-- 5 Aug 87 -- Reasons for DSS in military setting:

1. Capture institutional knowledge. Extremely important given the amount of turnover in most commands.

2. They may reduce time needed to make 'quality' decisions. They can handle mundane computations and massive data bases.

3. Commanders and planners need help in their fluid and unpredictable work environment.

-- 20 Aug 87 -- Subtask breakout of SOF force selection.

* Find 'common' subtasks that comprise the task of force selection and mission planning in general.

* Capture subtasks and let decision maker attack them as he/she sees fit. Provide a tool box in the form of a DSS.

* Capture user use profile in order to provide better tools for specific decision maker.

* Build the interfaces so planner can use the system in his 'language'. Make the system comfortable to use and orient on the subtasks identified earlier.

-- 20 Aug 87 -- IMplementation of large scale DSSs can be looked at using the Decision Support Analysis (DSA) approach. DSA has five elements: 1) Structured interviews of users; 2) DEcision analysis; 3) Data analysis; 4) Technical analysis; and 5) Management orientation. Overlay military equivalents and examine this approach.

-- 5 Nov 87 -- Target for my DSS is a prototype. Should be considered a version 0. It will be iterated repeatedly to obtain a functional system.

-- 5 Nov 87 -- Make the DSS for SOF selection usable for deployed command elements like a JSOTF. It might be needed to select units for follow on missions once deployed. This requires the system to be large enough to consider all

possible units allocated to the theater yet small and rugged enough to be deployed repeatedly. Micro-computer based?

-- 5 Nov 87 -- Is using commercial-off-the-shelf (COTS) software and hardware the way to go? Should we hard code a new system? Should I code my own DSS generator? OR Should I create a DSS generator using COTS such as VP Planner, dBase, Expert Choice, GURU, etc. as I need them?

-- 14 Nov 87 -- Emphasize the need for flexible, easy to use command and control/planning decision aids. DSS, by their very definition, should fit the bill. They should be easy to use, easy to learn, and most importantly, they should be help the organization to capture the institutional knowledge that units normally lose over time.

-- 9 Feb 88 -- How easy is it to construct a DSS with the current tools available, given minimal training in their use? (i.e., How easy is it to use spreadsheets, data bases, and expert systems for the uninitiated user?)

-- 9 Feb 88 -- How has my development of the DSS evolved from my original storyboards? Did the storyboards serve their purpose? How much did I capture?

DSS User

-- 5 Apr 87 -- DSS users must feel comfortable with the system. It has to be user friendly and easy to learn.

-- 20 Aug 87 -- Intermediaries should not be put between the decision maker and the DSS, if possible. Intermediaries can "contaminate" the decision by acting as filters, or injecting their own biases into the decision process. On the other hand, an intermediary may provide a balanced view of the problem. How do we deal with this two-edged sword?

Model Base

-- 1 Apr 87 -- The force selection process looks like a multi-criteria decision making (MCDM) problem. Could we include MCDM techniques in future versions? Could MCDM be used to compute values for input to the expert system?

-- 5 May 87 -- Model management problems.

* Models can restrict your approach to the problem.
* Models, to many people imply closed form solutions to problems. Some people take them as absolutes.
* How good do models have to be? How good is good enough?

* Models are hard to manage. The control of their grown and evolution is difficult. People tend to customize models without documenting their changes.

* Many models require different types of inputs. Hence, many models equal many data bases. Compatibility is a problem.

* How well do our models represent the world?

* What do model results mean to operational planners?

-- 2 Sep 87 -- Am I restricting the selection process by selecting a model around which to build my kernel? How can we insure a free flow in the decision process and not restrict the decision maker to a dogmatic approach in problem solving?

-- 9 Sep 87 -- SOTACA really is a DSS. It needs some expansion in its ability to capture thoughts and options. SOTACA also needs a front-end force selection mechanism.

-- 19 Sep 87 -- How do I overlay qualitative judgments on quantitative data? How do I capture the experience of operational planners in regard to the force selection process? What is the heirarchy I'm after? Do I emphasize facts over feelings, or feelings over facts?

-- 2 Feb 88 -- Much work needs to be done on the deployment model in PLANNER. It should include the number of aircraft required to lift a unit to the target area.

Expert Systems

-- 20 July 87 -- What if an expert system is imbedded in the DSS? Can it be used to conduct any kind of sensitivity analysis on the force selection decision? Could the system question itself?

-- 5 Nov 87 -- Should I look at an expert system to do the data base search for the best unit? I would use only the "if-then" capabilities of the system, i.e., the rule base. Don't worry about the inference engine at this point.

-- 14 Nov 87 -- Relooking expert systems. I wonder if they aren't too narrow in approach for the beginning of my DSS. The problem space they support is narrow and the answers may tend toward the dogmatic, i.e., they are based on an expert's knowledge. Not a whole lot of flexibility for the user. Perhaps expert systems can be used to capture knowledge as the system evolves.

-- 3 Dec 87 -- Expert systems could provide a way to match historical facts with present day situations to provide force and course of action selections. Must investigate.

Data base

-- 19 Aug 87 -- Thoughts.

* Big management problem. How do we get a handle on the data base management monster?

-- 5 Feb 88 -- Thoughts.

* Must find a way to interface PLANNER with existing systems in order to update information on units daily.

* The system must be tightly controlled in order to keep it safe from unauthorized or unintentional changes.

-- 21 Feb 88 -- Data base expansion. Make a data base file that displays recent training events for each unit. This may reflect the recency of training in perishable skills, such as mountaineering. This recency of training might prove a deciding factor in force selection.

SOF Doctrine

-- 1 Nov 87 -- All SOF units must have definite mission priorities. These units are critical to the United States' ability to respond in crisis. Even though most of these units are composed of elite troopers, they can't do everything well. The US must divide the SOF pie judiciously

in order to maximize the chances of mission success on any given day.

-- 6 Nov 88 -- Most literature available relating to SOF doctrine is conflicting. All services are very parochial. The "my force does it best" attitude is prevalent. We must deconflict these inter-service priorities to establish a coherent SOF doctrine.

-- 10 Jan 88 -- Special Operations are absolutely critical to US national security in today's world. We must be able to plan and execute SO better and more consistently than we do today. Can tools designed along the lines of PLANNER really help?

MAPP Applications

-- 25 May 87 -- Are MAPP tools targeted at the correct level? Would component commanders be better served by using MAPP tools in employment planning?

-- 5 Feb 88 -- Where do systems such as PLANNER fit in to the MAPP heirarchy?

Evaluation

-- 22 Aug 87 -- Evaluation structure.

* System, User, Organization, and Environment
* Four entities and three interfaces, all of them must be evaluated

-- 22 Aug 87 -- Evaluation benefits.

* Justification ---> Money and Budget
* User confidence ---> Is it worth the user's time?
* System improvement ---> Evolution of system
* System expansion ---> Evaluation supports
* Credibility ---> Can be established through evaluation

-- 23 Aug 87 -- Evaluation targets.

* What to evaluate?
* How to evaluate?
* When to evaluate?
* Efficiency or effectiveness? Both?

-- 23 Aug 87 -- General decision making tasks.

* Situation assessment
* Planning and commitment of resources
* Execution and monitoring
* Where do we start evaluation process?

-- 24 Aug 87 -- What to measure?

* Productivity measures are used to evaluate the impact of DSS on decisions.

* Process measures are used to evaluate the impact of the DSS on decision making.

* Perception measures are used to evaluate the impact of the DSS on decision makers.

* Product measures are used to evaluate the technical merits of the DSS.

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Vita

William Joseph Albinus Miller [redacted] 1975 [redacted] attended the University of Florida, from which he received the degree of Bachelor of Science in Business Administration, with honors, in December of 1979. He received a commission in the United States Army, Armor Branch, and attended the Armor Officer Basic Course at Ft. Knox, Kentucky. Upon graduation he completed an overseas tour in Scweinfurt, FRG, performing as Cavalry Platoon Leader, Troop Executive Officer, and Squadron Logistics Officer (S-4) for 3rd. Sqdn., 7th. Cavalry, 3rd. Infantry Division. Following graduation from the Infantry Officer Advanced Course at Ft. Benning, Georgia, in March 1984, he was assigned to 3rd. Sqdn., 3rd. Armored Cavalry Regiment at Ft. Bliss, Texas. There he served as the Commander of L Troop and Squadron Operations Officer (S-3). During his assignment with the 3rd. ACR, Captain Miller also graduated from the Combined Arms Service Staff School at Ft. Leavenworth, Kansas. In August of 1986 he entered the School of Engineering, Air Force Institute of Technology, Wright-Patterson, AFB, Ohio. Upon completion of his degree CPT Miller will be assigned to the Office of the Chief of Staff of th Army, the Pentagon.

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